VOL. 1, NO. 4, NOVEMBER, 1959

human factors

THE JOURNAL OF THE HUMAN FACTORS SOCIETY

Contents

A REACTION TIME STUDY OF FOUR CONTROL-DISPLAY LINKAGES 1
Alphonse Chapanis and Lionel E. Lindenbaum

EFFECTS OF RADIATION ON PERFORMANCE 8
Paul Tobias

THE MAGNITUDE AND DIRECTION OF FORCES THAT MAN CAN EXERT IN OPERATING AIRCRAFT EMERGENCY EXITS 16
Ernest B. McFadden, John J. Swearingen and C. D. Wheelwright

HUMAN FACTORS RESEARCH ON WEAPON SYSTEMS PROJECT TEAMS 28
Frederick A. Muckler

A MARGINAL PUNCHED CARD SYSTEM FOR HUMAN FACTORS LITERATURE 32
Carol S. Evans

THE TUFTS INDEX TO HUMAN ENGINEERING LITERATURE 47
Donald B. Devoe and Ezra V. Saul

HUMAN FACTORS IN MAN-MACHINE SYSTEMS 55
Harold E. Bamford, Jr.

DIRECTORY OF MEMBERS 60
Robert B. Sleight

BOOK REVIEW 82

THE AUTHORS 84

EDITORIAL 87

INDEX TO VOLUME 1 89

OHIO STATE UNIVERSITY JAN 15 1960 LIBRARY

PERGAMON PRESS NEW YORK • LONDON • PARIS • LOS ANGELES

OFFICERS AND EXECUTIVE COUNCIL

The Human Factors Society is a non-profit California Corporation. The officers and members of the Executive Council are:

PRESIDENT: Arnold M. Small, 1960
PRESIDENT-ELECT: Stanley N. Roscoe, 1960
VICE-PRESIDENT: Smith W. Ames, 1960
PAST-PRESIDENT: Renato Contini, 1960
SECRETARY: Paul G. Cheatham, 1960
TREASURER: Donald W. Conover, 1960
EDITOR-IN-CHIEF: Stanley Lippert, 1959-1961

EXECUTIVE COUNCIL:

Charles I. Barron, 1960-1962
Paul M. Fitts, 1959-1960
Jack A. Kraft, 1959-1960
Max W. Lund, 1959-1961
John Lyman, 1960-1962
Ross A. McFarland, 1959-1961

EDITORIAL BOARD:

Walter P. Grether
Blaine H. Levedahl
J. C. R. Licklider
Stanley Lippert
John Lyman
John P. Meehan
Allison K. Simons
Franklin V. Taylor
Neil D. Warren

HISTORIAN: Donald T. Hanifan

Address general correspondence to Human Factors Society, P. O. Box 263, Arlington 10, Virginia, Attention: **Paul G. Cheatham**, Secretary, for Society business including payment of dues.

Address matters pertaining to the Journal to **Human Factors**, Biotechnology Laboratory, Department of Engineering, University of California, Los Angeles 24, California, Attention:

John Lyman, Managing Editor, for Journal or Bulletin Subscriptions or other publication business.

Stanley Lippert, Editor-in-Chief, for submission of articles and letters to the editor.

Address Bulletin news to **Charles W. Simon**, 1030-F Fifth Street, Santa Monica, California.

COPYRIGHT ©, 1959
by the HUMAN FACTORS SOCIETY

PUBLISHED BY
PERGAMON PRESS, 122 E. 55th St., New York 22, N. Y.
4/5 Fitzroy Square, London W. 1. England.
Printed in U.S.A.

SUBSCRIPTION PRICE MEMBERSHIP in Society includes subscription to both publications. Journal. NON-MEMBERS SUBSCRIPTIONS TO BE SENT DIRECT TO THE PUBLISHER, PERGAMON PRESS. Commencing with Volume 2 the subscription price will be: $10.00 (£3.10s.) per annum, for individuals who certify that the journal is for their personal use. $20.00 (£7) per annum, for libraries, government establishments and research institutions.

Bulletin, $5.00 per year. Orders to be sent to John Lyman.

A Reaction Time Study of Four Control-Display Linkages[1]

ALPHONSE CHAPANIS and LIONEL E. LINDENBAUM, Department of Psychology, The Johns Hopkins University, Baltimore 18, Maryland.

Fifteen subjects were tested on each of four different wooden models of stoves containing various control-burner arrangements. The experiment measured reaction times and errors made by subjects who matched a control to a given burner as quickly as possible. Subjects were tested for 80 consecutive trials. The data show significant improvement in performance throughout the 80 trials. No significant improvement is evident in the second half of the trials, i.e., for trials 41 through 80. Analysis of the data for trials 41 through 80 shows one control-burner arrangement to be superior to all the others. Another arrangement is significantly worse than the best, but better than the remaining two.

INTRODUCTION

Look closely at any collection of gas and electric stoves and you are likely to find several different linkages between the controls and burners. This experiment evaluates four such linkages by measuring reaction times and errors made by subjects whose task was to match a control with a given burner as quickly as possible. Although observations on household ranges provided the primary motivation for this experiment, the results should be generalizable to certain other control-display applications. For example, control panels in electric substations are sometimes located in one plane while their associated displays are located at right angles to the control plane.

METHOD

Apparatus

The stoves used in this experiment were all of the four-burner variety with the burners on the horizontal surface and the controls on a vertical panel in front of the surface containing the burners (Fig. 1). The four arrangements illustrated in Fig. 1 are representative of stoves currently being manufactured, although the design labeled I is uncommon. The linkages illustrated in Fig. 1 do not, of course, exhaust all possible permutations. At least one other control-burner linkage is currently available on the market.

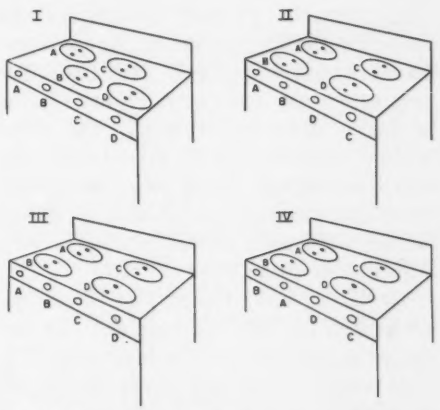


Fig. 1. The four control-burner arrangements used in this experiment. Note that the burners on stove I are staggered.

Wooden models of stoves were used in this experiment. All had the same dimensions: 18 in. wide, 24 in. long, and 6 in. high. The burners were represented by paper cut-outs in the center of which were two small lights. The upper light in each burner could be lit remotely by the experimenter. The lower one could be lit by pushing the appropriate control. Push button switches were used as controls.

[1] This article summarizes the results of an undergraduate thesis project carried out by Mr. Lindenbaum under the direction of the senior author. Chapanis is responsible for the design of the experiment, the analysis of the data, and the preparation of this article; Mr. Lindenbaum built the apparatus, scheduled and tested all the subjects. This work was done in part under Contract N5–ori–166, Task Order 1, Project Designation No. NR–145–089, and in part under Contract Nonr–248(55) between the Office of Naval Research and The Johns Hopkins University. This is Report No. 4 under the latter contract. Reproduction in whole or in part is permitted for any purpose of the United States Government.

EDUCATION LIBRARY

Procedure

At the beginning of a test session the experimenter demonstrated to each subject the control-burner linkage he was to use. Standardized instructions read to each subject informed him that he was always to start with his thumb on a starting button centered between the four controls and directly in front of the wooden model. When both subject and experimenter were ready the experimenter would give a ready signal and, shortly thereafter, turn on a stimulus light in one of the four burners. The subject's task was to match the stimulus light with its mate by pushing the correct control button as quickly as possible. The instructions emphasized that if the subject made an error he was to correct it immediately. The subject was then allowed to ask any questions he might have about his task. After these were resolved the subject was tested for 80 consecutive trials. Subjects were tested privately and individually. Test sessions lasted about 30 min.

The testing order for the four burners was randomized but with the restriction that each burner was tested exactly twenty times. The same test order was used for all subjects and all stoves.

The data for this experiment are reaction times and errors. A reaction time was defined as the length of time between the onset of the stimulus light and the pushing of the correct control button. An electric timer appropriately connected into the light circuits served as the measuring instrument. Errors were simply the number of times that subjects responded by pushing an incorrect button.

Experimental Design

The experimental design used in this study is shown in Table I. Fifteen different subjects were used on each stove. Each subject responded with 80 consecutive trials. Preliminary experiments with a few subjects seemed to show that there would be substantially little change in the average reaction times after about 40 or 50 trials. The subjects were volunteers from an introductory psychology class at The Johns Hopkins University.

RESULTS

Errors

Table II shows the total number of errors separately for the first 40 trials and for the last 40 trials. No errors were made on stove I. About 6% of all trials on stove II and about 10% of all trials on stoves III and IV were in error. The data also show a substantial re-

TABLE II

The Numerators Show the Total Number of Errors Made by 15 Subjects in Responding to Each of the Four Control-Burner Linkages in Fig. 1. The Denominators Show the Total Number of Trials on which the Error Counts are Based

Stove	*Trials 1–40*	*Trials 41–80*	*All trials*
I	0/600	0/600	0/1200
II	50/600	26/600	76/1200
III	73/600	43/600	116/1200
IV	70/600	59/600	129/1200

TABLE I

Experimental Design Used in this Study

	Stove I $S_1, S_2, \ldots, S_{15}$	*Stove II* $S_{16}, S_{17}, \ldots, S_{30}$	*Stove III* $S_{31}, S_{32}, \ldots, S_{45}$	*Stove IV* $S_{46}, S_{47}, \ldots, S_{60}$
Tr_1				
Tr_2				
Tr_3				
.				
.				
.				
Tr_{80}				

duction in the number of errors made from the first to the second half of the trials for stove II and a somewhat smaller reduction in the case of stoves III and IV. The numbers in the last column of Table II were analyzed by means of the Kruskal–Wallis one-way analysis of variance by ranks and were found to differ significantly ($p<0.001$). This significance, however, is due entirely to the fact that no errors were made on stove I. Another analysis of variance by ranks for stoves II, III and IV showed no significant differences between the errors made on them. The marked positive skewness and heteroscedasticity in the error distributions precluded the use of a somewhat more powerful parametric analysis of variance test.

Reaction Times

The reaction time data are shown in Fig. 2. Mean reaction times for stove I were consistently lower than for the other three stoves. Reaction times on stove II were somewhat higher than those for stoves III and IV at first but very quickly dropped below the data for stoves III and IV. Reaction times for stoves III and IV were about the same and uniformly higher than for the other two stoves.

Because of the marked improvement in performance throughout this experiment two separate analyses of variance were performed on the data to test the significance of the trends shown in Fig. 2. Table III shows the analysis of variance for data obtained on all 80 trials. Table IV shows a similar analysis of variance for the data obtained on the last 40 trials only. In addition, the trends were analyzed by the method of orthogonal polynomials.[1] Orthogonal polynomials allow one to examine independently the linear, quadratic, cubic, and higher order components in curvilinear regressions and to estimate the significance of the contribution of each of these components. Although the analyses were carried out to the quintic terms, the reductions in the sums of squares due to the quartic and quintic components were small and insignificant and so are not given in the tables.

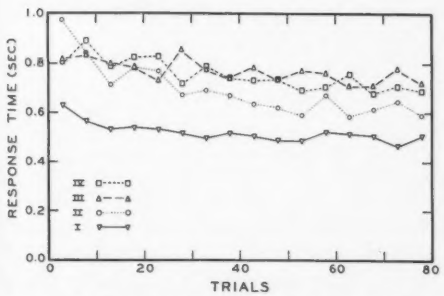


Fig. 2. Average times required to respond to each of the four stoves in Fig. 1. Each point is an average of 75 measurements (15 subjects times 5 trials).

Differences between stoves. Both Tables III and IV show that the differences between the means for stoves are highly significant. The data in Table IV are of special interest because they show that the differences between stoves are significant after learning is complete, that is, even though there is no longer any statistically significant improvement in performance from trial to trial (substantiation of this point is given below). The sums-of-squares column in Table IV shows that the variation between stoves accounts for a substantial proportion (about 16%) of the total variation in this set of data.

An analysis of variance tells us that there are significant differences among a set of means but does not identify which means differ significantly from each other. Application of Tukey's techniques for the comparison of individual means[3] to the data for all 80 trials shows that the mean for stove I is significantly lower than the mean for stove II, but that the means for stoves II, III, and IV do not differ significantly among themselves. The same tests applied to the data for the last 40 trials (after improvement has essentially stopped) shows that the mean for stove I is significantly lower than that for stove II and that the mean for stove II is significantly lower than that for stove III. The means for stoves III and IV do not differ significantly, of course.

TABLE III

Analysis of Variance of the Reaction Time Data for all 80 Trials

Sources of variance	*Sums of squares*	*Degrees of freedom*	*Estimates of population variance*	*F-ratios*
I. Between means for subjects	102.18	59		
A. Between means for stoves	46.21	3	15.40	15.40/1.00=15.40§
B. Between subjects within stoves	55.97	56	1.00	
II. Between means for trials	22.92	79	0.29	0.29/0.055=5.27§
A. Overall linear regression	10.66	1	10.66	10.66/0.21=50.76§
B. Deviations	12.26	78		
1. Quadratic component	1.50	1	1.50	1.50/0.083=18.07§
2. Deviations	10.76	77		
a. Cubic component	0.20	1	0.20	Not significant
III. Interaction: Trials × subjects	255.12	4661	0.055	
A. Interaction: Trials × stoves	22.69	237	0.096	0.096/0.053=1.81‡
1. Between linear regressions for stoves	2.72	3	0.91	0.91/0.21=4.33†
2. Deviations	19.97	234		
a. Between quadratic components	0.89	3	0.30	0.30/0.083=3.61*
b. Deviations	19.08	231		
(1) Between cubic components	0.27	3	0.09	Not significant
B. Interaction: Trials × subjects within stoves	232.43	4424	0.053	
1. Between linear regressions for subjects within stoves	11.49	56	0.21	
2. Deviations	220.94	4368		
a. Between quadratic components	4.65	56	0.083	
b. Deviations	216.29	4312		
(1) Between cubic components	5.02	56	0.09	
IV. Total	380.22	4799		

* Significant at the 0.025 level
† Significant at the 0.01 level
‡ Significant at the 0.005 level
§ Significant at the 0.001 level

Analysis of overall trend. Table III shows that the overall trend in the data is significant and that there is significant nonlinearity in the data. The nonlinearity can be accounted for adequately by a quadratic component. None of the higher order components — the cubic, quartic, or quintic — is significant. This analysis for overall trend (the sources of variance under II in Tables III and IV) is actually of little importance since it merely tells us what trend is evident if the data for all stoves are pooled.

Analysis of trends for stoves. Much more

TABLE IV

Analysis of Variance of the Reaction Time Data for Trials 41–80 only

Sources of variance	*Sums of squares*	*Degrees of freedom*	*Estimates of population variance*	*F-ratios*
I. Between means for subjects	48.13	59		
A. Between means for stoves	21.43	3	7.14	7.14/0.48 = 14.88§
B. Between subjects within stoves	26.70	56	0.48	
II. Between means for trials	3.49	39	0.089	0.089/0.034 = 2.62§
A. Overall linear regression	0.20	1	0.20	Not significant
B. Deviations	3.29	38		
1. Quadratic component	0.00	1	0.00	Not significant
2. Deviations	3.29	37		
a. Cubic component	0.12	1	0.12	Not significant
III. Interaction: Trials × subjects	78.02	2301	0.034	
A. Interaction: Trials × stoves	6.18	117	0.053	0.053/0.033 = 1.61‡
1. Between linear regressions for stoves	0.04	3	0.013	Not significant
2. Deviations	6.14	114		
a. Between quadratic components	0.04	3	0.013	Not significant
b. Deviations	6.10	111		
(1) Between cubic components	0.04	3	0.013	Not significant
B. Interaction: Trials × subjects within stoves	71.84	2184	0.033	
1. Between linear regressions for subjects within stoves	3.62	56	0.065	
2. Deviations	68.22	2128		
a. Between quadratic components	2.29	56	0.041	
b. Deviations	65.93	2072		
(1) Between cubic components	2.01	56	0.036	
IV. Total	129.64	2399		

‡ Significant at the 0.005 level
§ Significant at the 0.001 level

important are the sources of variance under III A in Table III. These tell us that significantly different amounts of improvement were made on the four stoves during the entire series of trials. These differences between the regressions for stoves are significant for both the linear and quadratic components. Differences between the cubic, quartic, and quintic components are not significant. The reasons for this outcome are apparent if one examines the data for each stove separately. Analyses of variance were performed on the data for each individual

TABLE V

Significances of Regression Components in the Data for Individual Stoves
Nonsignificant Components are in Parentheses

	Regression component	*Stove I*	*Stove II*	*Stove III*	*Stove IV*
All 80 trials	Linear	$p<0.001$	$p<0.001$	$(0.10>p>0.05)$	$0.005>p>0.001$
	Quadratic	$p<0.001$	$0.005>p>0.001$	$(p>0.50)$	$(0.10>p>0.05)$
	Cubic	$0.005>p>0.001$	$(0.25>p>0.10)$	$(p>0.50)$	$(p>0.50)$
	Quartic	$0.025>p>0.01$	$(p>0.50)$	$(p>0.50)$	$(p>0.50)$
	Quintic	$(0.10>p>0.05)$	$0.025>p>0.01$	$(p>0.50)$	$(p>0.50)$
Trials 41–80 only	Linear	$(p>0.50)$	$(p>0.50)$	$(p>0.50)$	$(0.50>p>0.25)$
	Quadratic	$(p>0.50)$	$(p>0.50)$	$(p>0.50)$	$(p>0.50)$
	Cubic	$(p>0.50)$	$(0.10>p>0.05)$	$(p>0.50)$	$(0.25>p>0.10)$
	Quartic	$0.025>p>0.01$	$(p>0.50)$	$(p>0.50)$	$(p>0.50)$
	Quintic	$0.01>p>0.005$	$0.025>p>0.01$	$(p>0.50)$	$(p>0.50)$

stove and the outcomes of the tests for trends are shown in Table V. There it is clear that although the trends for stoves I, II, and IV are significant, there is no significant trend in the data for stove III. Another way of saying this is that there is no statistically significant reduction in reaction times on stove III throughout the entire series of 80 trials. Table V also shows that the data for stove IV can be adequately fitted by a linear regression line. There is no statistically significant nonlinearity in the data for this stove.

Table IV gives the analysis for the last 40 trials of the experiment. In contrast to the analysis in Table III there are no significant trends evident in the data for the last 40 trials. Table V shows also that there are only three significant regression components out of 20 in the data for individual stoves across the last 40 trials. The three which are statistically significant are so small as to be of no practical importance.

Differences between trials. Finally, Table IV also shows that there is still a significant difference between the means for trials even though there are no statistically significant trends in the data. This arises from the fact that the mean reaction times to the four controls are different. The significant trials–times–stoves interaction is of little practical importance since it merely tells us that the mean reaction time to any particular control is a function of the total pattern in which it appears. For example, the difficulty of using the extreme left-hand control depends upon whether it is used in stove II or IV.

DISCUSSION

The results of this experiment show that a control–display arrangement like that in the upper left-hand corner of Fig. 1 is clearly superior to the other three. Linkage pattern II is next best while III and IV are about equally bad. The results for pattern I are what most people expect since the compatibility between the arrangement of controls and displays is so obvious as to require little comment. Isomorphism between the arrangement of the controls and displays is much less obvious for patterns II, III, and IV, and, perhaps for this reason, the opinions of naive persons seem to be equally divided between the three when they are asked to vote on the second-best pattern. With the results of the experiment before us, however, it is easy to infer a certain compatibility between the controls and displays in pattern II if one thinks of the control arrangement as simply "wrapped around" the top surface. The logical reasons which many people adduce to support their beliefs that patterns III or IV should be easy to use are not supported by the experimental facts.

Three interesting questions remained unanswered: (1) Would the same results be obtained

if housewives had been tested instead of college students? (2) How would still other control-burner arrangements compare with those tested here? (3) What would the results look like if prolonged training, extending over several months, had been used? A recent study by Mowbray and Rhoades[2] shows that reaction times can be measured under experimental conditions which yield statistically significant differences between means so long as practice is confined to no more than a few thousand trials. With sufficient practice, however (after approximately 35,000 practice trials in the Mowbray–Rhoades study), the mean reaction times may no longer be significantly different. At any rate, it seems safe to conclude that control–display linkages will differ significantly for those practical situations in which there is no opportunity for intensive concentrated practice.

REFERENCES

1. GRANT, D. A., Analysis-of-variance tests in the analysis and comparison of curves. *Psych. Bull.*, **53**, 141, 1956.

2. MOWBRAY, G. H., and RHOADES, M. V., On the reduction of choice reaction times with practice. *Quart. J. Exp. Psych.*, **11**, 16, 1959.

3. TUKEY, J. W., Comparing individual means in the analysis of variance. *Biometrics*, **5**, 99, 1949.

Effects of Radiation on Performance

PAUL TOBIAS, Human Factors, Missile Division, North American Aviation; now at Kerckhoff Laboratories, School of Medicine, University of Southern California.

The experimental studies relating to the effect of various types of radiation on learning, activity and manipulation, conditioning, and discrimination are discussed. The difficulty of inferring an effect in man, and the confounding due to uncontrolled variables are highlighted. Recommendations for further experimental studies are presented, and a comprehensive bibliography of selected material on radiation is included.

INTRODUCTION

Current interest in the effects of radiation on performance is threefold: nuclear power, cosmic radiation, and atom bomb radiation. This discussion is not concerned with bomb radiation, which is covered extensively elsewhere.[23] The problem at hand is man's exposure to radiation through his daily work with nuclear engines or through space travel and the effect this will have on his performance, even when the dose is sublethal.

This discussion concerns mainly x-ray or gamma radiation because few other sources have been used in studies on performance. Material radiations, the other sources, are essentially a stream of particles which transfer their energy to the absorbing media. These particles, differing in mass and charge, include neutrons, alpha particles, electrons (beta particles), deuterons and photons. Obtaining and handling particulate radiation is very difficult, while the use of x-ray techniques is simpler by comparison.

The major difficulty in using any radiation in experimental studies of performance is that many variables must be controlled or accounted for. These include the following:

Quantity of radiation
Rate of absorption
Type of radiation
Manner of exposure
Species differences
Sex differences
Condition of organism
Drugs and anoxia
Reproductive activity
Area of exposure

In addition, confounding due to altered motivation is possible. Stressor activity to the pituitary causing an adrenocortical stress response is another factor.

The problems already mentioned are distinctly minor when compared to that of discovering what effects occur in man. The possibility of inferring an effect on man from studies on subhuman animals has been considered. Based on available lethality data, McLean[16] believes that many extensions can be made. The problem is even more serious when the effect on performance is considered. At present, it can only be stated that, if an effect is noted in subhuman animals, it may also occur in humans. However, it is invalid to state this negatively, because human perception and response processes differ widely from other animals.

This review may offer an insight to the current status of the problem, and some experiments may be suggested from it. The intensities of radiation in the Van Allen belts and the frequency of exposure of personnel to radiation from nuclear engines and reactors, demand a thorough understanding of the effects of subleathal radiation upon variables of performance.[6]

LEARNING

One of the first experiments on the effect of radiation on learning was performed by Furchtgott[7] in 1951 using escape from a water maze as the learning motivation. In the first section of this experiment, 32 rats were subjected to whole body radiation of either 200r or 300r. Furchtgott found no difference between the control and

the experimental subjects for either level of radiation, as measured on new learning and retention. In the second part of the experiment, 34 rats were subjected to 500r, 20 rats to 400r, and 27 rats to 300r. It was found that retention measured by maze time was significantly poorer for the 500r group. No effect on maze errors was found for any group.

The effects of radiation upon retention as well as other variables was studied by Kaplan[12] and published by the School of Aviation Medicine in 1951. This study deserves a fuller analysis since it is characteristic of the majority of experiments in this area.

Eighty-seven male albino rats of the Sprague-Dawley strain were used. Sixty-one of these animals were used in the maze experiment, which was a slightly modified version of Lashley's Maze III. A four-foot alley straightaway was used for preliminary training. The radiation source was a deep therapy x-ray machine (250 kv, 15 ma; 0.5 mm copper and 1.0 mm aluminum filters). The container did not preclude all movement by the animals; however, any variations in the total air dose delivered at the tops of the animals' backs were on the order of less than $\pm 3\%$. Radiation was given at the rate of approximately 30r/min.

The animals were pretrained in the straightaway to establish a goal seeking habit. The goal was pellets of food which the animals were permitted to eat for 30 sec. The animals received 15 trials on the maze and then the experimental group received 90, 180, 360 or 600r. Eighteen hours later the 16th trial was commenced. This procedure points to a basic flaw in the experimental design. Since gastrointestinal effects of radiation are a general malaise and inability to hold down food, the behavioral effects, or more specifically lack of effects, may be due to gastrointestinal difficulties in the irradiated animals. Kaplan states that the only significant results were longer running times and poorer error scores for the rats receiving 600r. This is hardly surprising, since half of the 600r group died within 30 days. This confounding effect, using food as a goal, is common to many of the experiments covered in this review. On two of them, a delay between radiation and testing was introduced; this delay, in one case 18 months, seems sufficient to overcome the confounding effect based upon physiological examination.

In 1952, Arnold[1] used 12 rats in a maze experiment with a hunger drive to study the effect on retention of a 300r dosage, restricted to the cranium. He found no significant differences in maze errors or maze time when the radiation group was compared with a control group. In a second experiment, he used 800r applied to the cranium, using rats in a maze with a hunger drive. Again he found no significant differences. Kaplan,[11] in 1953, tried another approach with four monkeys. He shielded the central nervous systems of two of the animals and studied their ability to transfer on a stimulus paired discrimination task after receiving 400r. The monkeys receiving this dose, two whose central nervous systems were not shielded, and two with shielding, showed no significant differences from controls.

In 1954, Melching,[17] as part of the School of Aviation Medicine program, tried using a whole body radiation of 1500r on four monkeys and testing them for retention on a Y-shaped maze with a shock avoidance motivation. Again, no significant variation was found. Rogers,[20] on this same project, in 1954, used cumulative doses of 108r for 12 trials on two monkeys and then tested them on tasks involving discrimination learning, retention, and transfer. No significant results were obtained.

The first contradictory results were reported in 1956 by Riopelle[19] who divided 28 monkeys into three groups. One group received a single dose of 350r, a second, 10 doses of 100r, and the third, 10 doses of 200r. Hunger was used as a drive. A significant increase of discrimination learning in the irradiated groups was observed, but no effect was noted on avoidance learning or on a direct method of delayed response. Riopelle felt that the increment in performance could be due to either an increased resistance to distraction or to increased tameness.

The picture was further complicated when Blair,[2] 1956, found an initial decrease in the learning retention of 20 rats during maze performance after a 2500r dosage, restricted to the cranium. However, a significant later improvement in learning retention was found when the treated group was compared with a control group. He theorized that this was due to a higher hunger motivation and a decrease in exploratory drive.

What is perhaps the most complete study was reported by Fields,[5] in 1957. He used 180r and 360r whole body radiation on two groups of 20 rats each and tested them on maze learning with a hunger drive. He reported a significant increase in straightaway and maze time for the 360r group, but significantly fewer errors for this same group. Next he used radiation levels of 100r, 200r, 400r, and 600r and found that learning retention was significantly poorer for the 600r group and that 94% of the group died within 11 days. Another part of this same experiment investigated the effect of 100r, 200r, and 400r whole body radiation on relearning after a 6 month delay. No significant increase or decrease was found for straightaway time or maze time; however, there was a significant increase in maze errors for the 200r and 400r groups. A fourth section of this study tested the effect of 400r, 800r, and 1000r on hunger motivated rats tested in a vertical maze. Although no significance was found for maze time, the 1000r group showed a significant increase in maze errors when compared with the 400r, 800r, and control groups.

The most recently reported experiment in this area was undertaken by Blair[3] in 1958. He used 5000r cranial radiation in 34 hunger-motivated rats and found a significant decrease in both maze time and maze errors as measures of learning retention. This substantiates his earlier results.

When the data presented here are categorized by species and lethality, it appears that there is no effect from lethal x-irradiation on learning and retention of learning in monkeys. Rats, on the other hand, seem to respond to a massive lethal dose with faster maze time and fewer errors. The only indication of the effect of a sublethal dose on monkeys is an improvement of discrimination learning. Below 350r there seems to be no effect on rat learning in a maze, and, between 350r and a lethal dose, evidence largely indicates a decrement in performance.

ACTIVITY AND MANIPULATION

There are four studies with direct bearing on the effects of x-ray on activity and manipulation. The first of these was undertaken by Leary,[13] in 1955. He used cumulative doses of 50r on monkeys after an initial dose of either 100r or 200r with the total dose 200r, 300r, or 400r. Post radiation trials were commenced the same day and continued for 5 weeks. He found no significant difference in activity, as measured by a penmotor, between the groups or between a treated and control group. In the 400r group, no significant change was indicated on a motivated weightpulling task, although observed activity and manipulatory ability, as measured by a pedometer, showed significant decrease. Leary feels that these results support the hypothesis that low-motivated behavior is most susceptible to the effects of ionizing radiation.

Davis,[4] reporting in 1956 on a study of manipulation, found that monkeys subjected to 400r whole body radiation differed significantly from control animals in only two out of six tasks. There was a significant increase in failures in a bent wire, poker chip task and there was significantly less chewing of a wood block. Post radiation trials were commenced the same day and continued for 64 days. In this study, Davis reports some unpublished data of McDowell which indicated that, at 400r radiation, monkeys showed a significant decrease in hand and oral manipulation.

Riopelle,[19] using a single dose of 250r, 10 doses of 100r, and 10 doses of 200r on hunger-motivated monkeys, found significantly less activity in a 1956 study, when post radiation

trials were conducted during administration of multiple doses and in some cases continued for two to four months. Fields[5] obtained similar results in 1957 with 360r radiated and hunger-motivated rats on an activity drum, tested forty-two days after radiation.

Generally, it would appear from these studies that radiation, in both lethal and sublethal doses, serves to decrease activity and manipulation rates in both rats and monkeys.

CONDITIONING

Nemenow,[18] reporting in 1933 on what is perhaps the first behavioral experiment with x-ray, found a temporary slight decrease in a salivary conditioned response in two dogs after 1500r, 3500r and multiple dosage to 6300r applied to the cranium. Nemenow began post radiation trials 12 days later and continued them for ten weeks or until death of the experimental dog terminated the test. In the same year, Lyman,[15] also at the Pavlov Laboratory, found that the salivary conditioned response in dogs temporarily decreased after 17,000r radiation, when testing was begun 3 days after radiation and was continued for 6 months or until death of the experimental subjects. The only other reported work with conditioned response was described by Garcia[9] in 1955. Garcia found a significant decrease in saccharin intake of rats conditioned to an aversion to saccharin and then irradiated with either 30r or 57r. Post radiation trials were run the following day and continued for sixty-three days. This study is noteworthy because an effect was found with a low level of radiation, and the effect was proportional to the radiation dose.

DISCRIMINATION

Furchtgott,[8] in a study published in 1952, found that brightness discrimination in rats was significantly poorer after 369r and 490r whole body radiation by x-rays.

Two studies by Warren[21, 22] represent the only experiments on discrimination using sublethal radiation sources other than x-ray. It would be well to consider in some detail the first of these studies, since it is experimentally more sound than most of the other studies discussed in this paper.

Ten experimentally naive rhesus monkeys were studied. Three were normal and seven were irradiated. The Wisconsin General Test Apparatus was used in this experiment. This is essentially a restraining cage behind a table on which a wheeled tray carrier was set, containing food wells. The stimuli were 108 different pairs of objects, differing in multiple visual dimensions. The Oak Ridge National Laboratory "Bulk Shielding" reactor was utilized as a source of fast neutron and gamma radiation. Cumulative dose procedures were utilized and the doses are listed as follows:

Average Radiation Dose

	Gamma radiation (r)		*Neutron radiation (dose in rem, based on neutron/gamma RBE of 10)*
Group	Head	Body	Head and body
A	25	18.5	7.4
B	107	87.0	30.0
C	493	404.0	118.0

Psychological testing of the subjects was begun approximately eight months following the last radiation exposure. (This controls the possible confounding due to gastrointestinal effects upon hunger drive.) Three discrimination reversal problems were presented daily for 36 working days; thus, the total number of problems was 108, of which 18 problems were presented under each of six conditions of prereversal reinforcement.

Warren found that the performance of the irradiated group was consistently inferior to the performance of the control group. The normal monkeys averaged 68% correct responses while the irradiated group had a mean of 16%. The

differences between these groups was tested with the Mann-Whitney nonparametric test for ranked data and was significant at the 0.017 level.

Davis,[4] as published in 1956, studied object discrimination of eight monkeys after receiving 400r whole body x-radiation. On four tests he found no significant differences.

In summary, it appears that radiation does impair discrimination processes although not all evidence is in agreement.

PERFORMANCE AFTER COSMIC RADIATION

The only study on performance after cosmic radiation reported to date is one by Harlow[10] in which monkeys were sent in a ballon to 90,000 ft altitude. No significant differences were found on five types of discrimination problems after this exposure to cosmic radiation. It should be noted, however, that this experiment was performed in an environment not adequately controlled, and that the radiation dose was not clearly established.

CONCLUDING REMARKS

The available literature on the effect of radiation on performance which has been evaluated and summarized in the preceding pages does not come near answering the question of immediate concern, "What changes in performance might result from the daily exposure of man to sublethal doses from atomic or nuclear engines and from cosmic rays in space travel?" The work that has been done in the laboratory has been done on subhuman animals, many times with lethal doses, and many times with uncontrolled confounding variables present. In addition, the results obtained from these studies are sometimes quite contradictory, and little generalization is valid. Some definitive steps are immediately apparent.

1. In animal experimentation an extremely sensitive apparatus is needed to test the effect of sublethal material radiation on performance. This could be done using the Krech-Rosensweig hypothesis box. Since Krech and Rosensweig found a significant correlation between rat behavior and cholinesterase concentration in the brain, and since cholinesterase is affected by low levels of radiation (Lundin[14]) this should prove fruitful. In doing this experiment, the confounding due to radiation-produced gastrointestinal effects must be controlled. Further, the radiation exposure should cover a long period of time to simulate the type of condition of primary interest in industry.

2. A realistic space radiation study is necessary. This may be in process at this time. However, it is well to state here some outline of such a study. Animals need to be orbited into space in a capsule which will provide a test situation perhaps similar to a Skinner lever pressing, conditioned-response testing apparatus. The animals performance would be studied as a function of the level and type of radiation encountered. This type of study should include a multivariate analysis of pressure, temperature and, of course, physiological variables.

3. One experimental approach as yet untried and perhaps the most relevant would entail the testing of performance on people who today are exposed daily to radiation through their work with atomic reactors. The serious problem here is to find a sensitive measurement device and to provide an adequate control group. This latter might be done by using new hires and equating the groups on the basis of a combination of tests such as the Employee Aptitude Survey and the Guilford-Zimmerman Temperament Test.

4. Finally, it would be well to state the conviction that, where biochemical changes result from sublethal radiation as previously mentioned, changes in behavior will be found if the measuring instrument is sufficiently sensitive, since it is impossible and unrealistic to disassociate psychological effect from physiological effect. The urgency of this situation is very real. A maximum permissible dose refers only to pathological damage and death. Below this point exposure, which is considered acceptable, may result in deleterious effects evidenced by changes in performance.

Summary of Experimental Results of the Effect of Radiation on Performance

Performance variable	*Species*	*Radiation dose received*	
		Lethal	*Sublethal*
Learning	Monkeys	No effect	Improvement
	Rats	Faster time and fewer errors	Decrement or no effect
Activity and manipulation	Monkeys	Decrease	Decrease
	Rats	Decrease	Decrease
Conditioning	Dogs	Decrement	.....
	Rats	.....	Decrement
Discrimination	Rats	Decrement	.....
	Monkeys	Decrement	Decrement

BIBLIOGRAPHY

1. ARNOLD, W. J., Maze learning and retention after x-radiation of the head. *J. Comp. Physiol. Psych.*, **45**, 358, 1952.

2. BLAIR, W. C., and ARNOLD, W. J., The effects of cranial x-radiation on retention of maze learning in rats. *J. Comp. Physiol. Psych.*, **49**, 525, 1956.

3. BLAIR, W. C., The effects of cranial x-radiation on maze acquisition in rats. *J. Comp. Physiol. Psych.*, **51**, 175, 1958.

4. DAVIS, R. T., MCDOWELL, A. A., DETER, C. W., and STEELE, J. P., Performance of rhesus monkeys on selected laboratory tasks presented before and after a large single dose of whole-body x-radiation. *J. Comp. Physiol. Psych.*, **49**, 20, 1956.

5. FIELDS, P. E., The effect of whole-body x-radiation upon activity drum, straightaway and maze performance of white rats. *J. Comp. Physiol. Psych.*, **50**, 386, 1957.

6. FREDEN, S. C., and WHITE, R. S., Inner Van Allen radiation belt identified Missiles and Rockets. *American Aviation Publications, Inc.*, June 15, 1959.

7. FURCHTGOTT, E., Effects of total body x-irradiation in learning; an exploratory study. *J. Comp. Physiol. Psych.*, **44**, 197, 1951.

8. FURCHTGOTT, E., The effects of x-irradiation on brightness discrimination. *J. Psychol.*, **34**, 37, 1952.

9. GARCIA, J., KIMELDORF, D. J., and KOELING, R. A., Conditioned aversion to saccharin resulting from exposure to gamma radiation. *Science*, **122**, 157, 1955.

10. HARLOW, H. F., SCHRIER, A. M., and SIMONS, D. G., Exposure of primates of cosmic radiation above 90,000 feet. *J. Comp. Physiol. Psych.*, **49**, 195, 1956.

11. KAPLAN, S. J., and GENTRY, G., Some effects of sublethal dose of x-radiation upon transfer of training in monkeys. USAF SAM Project No. 21–3501–0003 Rep. No. 4, December 1953.

12. KAPLAN, S. T., TAIT, C. D., WALL, P. D., and PAYNE, R. E., Behavioral changes following radiation: 1. Study of retention of a partially learned maze habit. Unnumbered Project, Rep. No. 1, USAF School of Aviation Medicine, Randolph Field, Texas, March, 1951. 2. Maternal behavior and maze performance. USAF, School of Aviation Medicine, Special Report, July 1952.

13. LEARY, R. C., and RUCH, T. C., Activity, manipulation drive, and strength in monkeys subjected to low level radiation. *J. Comp. Physiol. Psych.*, **48**, 336, 1955.

14. LUNDIN, J., CLEMEDSON, C.-J., and NELSON, A., Early effects of whole body irradiation on cholinesterase activity in guineapigs' blood with special regard to radiation sickness. *Acta. Radiol.*, **48**, 52, 1957.

15. LYMAN, R. S., KUPALOV, P. S., and SCHOLZ, W., Effects of roentgen rays on the central nervous system. *Arch. Neurol. Psychat., Chicago*, **29**, 56, 1933.

16. MCLEAN, F. G., RUST, J. H., and BUDY, A. M., Extension to man of experimental whole-body radiation studies. *Military Surgeon*, **112**, 174, 1953.

17. MELCHING, W. H., and KAPLAN, S. J., Some effects of a lethal dose of x-radiation upon retention: Studies of shock avoidance motivation. USAF SAM Project No. 21–3501–0003, Rep. No. 9, August 1954.

18. NEMENOW, M. I., The effect of roentgen ray exposure of the cerebral hemispheres. *Radiology*, **23**, 86, 1933.

19. RIOPELLE, A. J., GRODSKY, M. A., and ADES, H. W., Learned performance of monkeys after single and repeated x-radiations. *J. Comp. Physiol. Psych.*, **49**, 521, 1956.

20. ROGERS, C. M., KAPLAN, S. J., GENTRY, G., and AUXIER, J. A., Some effects of cumulative doses of x-radiation upon learning and retention in the rhesus monkey. USAF SAM Rep. No. 21–3501–0003, Rep. No. 11, November 1954.

21. WARREN, J. M., and KAPLAN, S. J., A study of discrimination learning in monkeys with implications for the investigation of the psychobiological effects of ionizing radiation. USAF SAM Project No. 21–3501–0003 report No. 6, July 1954.

22. WARREN, J. M., KAPLAN, S. J., and GREENWOOD, D. D., The solution of discrimination reversal problems by normal and irradiated monkeys. USAF, School of Aviation Medicine, Proj. Rep. 1955, Proj. No. 21–3501–0003, Rep. No. 16.

23. National Bureau of Standards: Recommendation of the international commission of radiological protection and of the international commission on radiological units, 1950. National Bureau of Standards Handbook 47.

SELECTED SUPPLEMENTAL BIBLIOGRAPHY

1. BACHOFER, C. S., Enhancement of activity of nerves by x-rays. *Science,* **125**, 1140, 1957.

2. BIRGE, A. C., Laboratory studies for evaluating the biological effects of primary cosmic radiation. *J. Aviat. Med.,* **25**, 326, 1954.

3. CAMPBELL, B., A biological study of the effects of the heavy particle component of cosmic rays. *J. Aviat. Med.,* **25**, 361, 1954.

4. CASTER, W. O., REDGATE, E. S., and ARMSTRONG, W. D., Changes in the central nervous system after 700r total body x-radiation. *Radiation Research,* **8**, 92, 1958.

5. CLARK, E., Pioneer indicates restricted radiation. *Aviation Week,* **69**, No. 16, 30, 1958.

6. ELDERD, E., and TROWBRIDGE, WM. V., Neurological and EEG findings in the monkey after total body x-irradiation. *EEG Clin. Neurophysiol.,* **5**, 259, 1953.

7. FURCHTGOTT, E., Behavioral effects of total body x-irradiation in the rat: an exploratory study. Ph.D. Thesis, University of California (unpublished) 1950.

8. FURCHTGOTT, E., Behavioral effects of ionizing radiation. *Psychol. Bull.,* **53**, 321, 1956.

9. GERSTNER, H. B., Military and civil defense aspects of the acute radiation syndrome in man. School of Aviation Medicine, Randolph AFB, Texas, AF–SAM–58–6. July 19, 1957.

10. GOLUBTSOVA, A. V., MOISEENKO, E. V., and SAFRONOVA, M. I., Changes in cerebellum tissue metabolism with irradiation by x-rays. *Bull. Exp. Biol. Med.* (*USSR*) **41**, 763, 1956.

11. HAGEN, J. P., The Vanguard project. *J. Aviat. Med.,* **28**, 503, 1957.

12. HOWARTH, J. L., Dosimetry of ionizing radiations. In, "Aviation Medicine, Selected Reviews," C. S. White, W. R. Lovelace and F. G. Hirsch (Eds.), Pergamon Press, London, 1958.

13. KAPLAN, S. J., and THOMAS, G. E., The research program for the University of Texas. USAF SAM Primate Laboratory Project No. 21–3501–0003, Rep. No. 1, October 1953.

14. KAPLAN, S. J., and GENTRY, G., Some effects of a lethal dose of x-radiation upon memory. A case history study. USAF SAM Project No. 21–3501–0003, Rep. No. 2, June 1954.

15. KAPLAN, S. J., and GENTRY, G., A general test apparatus for infrahuman primates. USAF SAM Project No. 21–3501–0003, Rep. No. 3, September 1953.

16. KAPLAN, S. J., GENTRY, G., MELCHING, W. H., and DELIT, M., Some effects of a lethal dose of x-radiation upon retention in monkeys. USAF SAM Project No. 21–3501–0003, Rep. No. 8, August 1954.

17. KONECCI, E. B., Tolerance to simulated altitude after whole body x-irradiation in guinea pigs. *J. Aviat., Med.,* **26**, 130, 1955.

18. KONECCI, E. B., and DANFORD, M. B., Biological and medical aspects of ionizing radiation: spinal reflex activity and local x-radiation. USAF School of Aviation Medicine, Rep. No. 56–90, 1956.

19. KONECCI, E. B., Calculations of the radiobiological risk factors involved in future nuclear powered space vehicles. 30th Annual Aero Medical Convention, April 1959.

20. KRECH, D., ROSENZWEIG, M. R., and BENNET, E. L., Dimensions of discrimination and level of cholinesterase activity in the cerebral cortex of the rat. *J. Comp. Physiol. Psych.,* **49**, 261, 1956.

21. LOONEY, W. B., Effects of radiation in man. *Science,* **127**, No. 3299, 1958.

22. MALIS, L. I., LOEVINGER, R., KRUGER, L., and ROSE, J. E., Production of laminar lesions in the cerebral cortex by heavy ionizing particles. *Science,* **126**, 302, 1957.

23. MCDOWELL, A. A., DAVIS, R. T., and STEEL, J. P., Application of systematic direct observational methods to analysis of the radiation syndrome in monkeys. *Percept. Mot. Skills,* **6**, 117, 1956.

24. NEARY, G. J., MUNSON, R. J., and MOLE, R. H., "Chronic Radiation Hazards. An Experimental Study with Fast Neutrons." Pergamon Press, New York (QH652 N27C) 1957.

25. REID, J. B., KAPLAN, S. J., and MELCHING, W. H., A method for analysis of gross behavior. USAF SAM Project No. 21–3501–0003, Rep. No. 10, June 1955.

26. ROSENFIELD, G., The function and capacity of the adrenal cortex immediately before radiation sickness. *J. Lab. Clin. Med.,* **51**, 198, 1958.

27. SCHAEFER, H. J., Theory of the protection of man in the region of the primary cosmic radiation. *J. Aviat. Med.,* **25**, 338, 1954.

28. SCHAEFER, H. J., Definition of a permissible dose for primary cosmic radiation. *J. Aviat. Med.,* **25**, 392, 1954.

29. SCHAEFER, H. J., Optimum altitudes for biological experimentation with the primary cosmic radiation. *J. Aviat. Med.,* **27**, 512, 1957.

30. SCHAEFER, H. J., New knowledge of the extra-atmospheric radiation field. *J. Aviat. Med.,* **29**, 492, 1959.

31. SCHAEFER, H. J., Radiation doses in flight through the radiation belt. 30th Annual Aero Medical Convention, April 1959.

32. SHEPHERD, L. R., The possibility of cosmic ray hazards in high altitude and space flight. *J. Brit. Interplan. Soc.,* **12**, 197, 1953.

33. SIMONS, D. G., and PARKS, D. P., Improved techniques for exposing animals to primary cosmic ray particles. *J. Aviat. Med.,* **27**, 317, 1957.

34. STONE, R. S., The concept of maximum permissible exposure. *Radiology,* **58**, 639, 1952.

35. STORER, J. B., FURCHNER, J. E., and KREBS, A. T., Specific ionization and relative biological effectiveness of ionizing radiations in mammalian systems. *J. Aviat. Med.,* **25**, 368, 1954.

36. TOBIAS, C. A., Radiation hazards in high altitude aviation. *J. Aviat. Med.,* **23**, 345, 1952.

37. VAN ALLEN, J. A., LUDWIG, G. H., RAY, E. C., MC ALWAIN, C. E., Observation of high intensity

radiation by satellites. 1958 Alpha and Gamma (Explorer I and III). *Jet Propulsion,* **28**, 588, 1958.

38. WHITE, C. S., and BENSON, O. O. (Eds.), "Physics and Medicine of the Upper Atmosphere, a Study of the Aeropause." University of New Mexico Press, Albuquerque, 1952.

1. BURNIGHT, T. R., Uultraviolet radiation and x-rays of solar origin, pp. 226–238.

2. VAN ALLEN, J. A., The nature and intensity of the cosmic radiation, pp. 239–266.

3. KREBS, A. T., The biologic effects of laboratory radiation, pp. 267–289.

4. SCHAEFER, H. J., The biologic effects of cosmic radiation, pp. 316–330.

5. KREBS, A. T., Methods of assuring the biologic effects of ionizing radiation and methods of measuring it, pp. 471–478.

6. EVANS, T. C., A discussion of the potential effects on man of ionizing radiation present in the upper atmosphere, pp. 533–539.

7. TALBOT, J. M., The biological effects of power plan radiation, pp. 540–543.

8. BUETTNER, K., Biological effects of radiation of possible extraterrestrial origin, pp. 544–547.

39. Explorer IV Data, *Astronautics,* 3, No. 9, 1958.

The Magnitude and Direction of Forces that Man can Exert in Operating Aircraft Emergency Exits

ERNEST B. McFADDEN, JOHN J. SWEARINGEN, and C. D. WHEELWRIGHT,
Civil Aviation Medical Research Laboratory, FAA Aeronautical Center, Oklahoma City, Oklahoma.

The maximum forces that men and women were capable of applying to emergency exit release handles under various conditions were determined. Experiments were conducted on both port and starboard sides of a cabin mockup simulating the interior of the Convair 240. Approximately 339 determinations of the maximum force that 17 female subjects were capable of applying to emergency exit handles were obtained. This study was extended to include measurement of the resultant force and its direction with 112 tests conducted by eight female subjects, of which three participated in the above series. In addition 162 tests were conducted by nine male subjects, and a few tests on six children. The effects of handle configuration, location, position of the subject, and the duration of the muscular contraction are discussed.

INTRODUCTION

For rapid and efficient emergency evacuation of aircraft it is desirable that various human aspects of exit operational capability be evaluated. Information in regard to emergency exit handle configuration, mode of operation, and maximum forces that may be applied to emergency exit release mechanisms were needed for the establishment of operational design and structural standards. Cooperating with the Committee for Aircraft Cabin Safety Standardization (S-9) of the SAE, the Civil Aviation Medical Research Laboratory conducted a series of tests in order to provide this committee with an experimental basis for the establishment of emergency exit standards.

A previous paper[1] describes measurements of the maximum torque that can be applied in the rotational operation of main cabin door handles. The evaluation of emergency exit operation involves a different set of parameters. It is the purpose of this paper to describe measurements of the maximum pulling force that can be exerted for the operation of emergency exit release mechanisms. The first series of measurements was limited to women and a few children. In Series 1 the horizontal force was measured, and several handle configurations evaluated. In the last series of observations (Series 2), instrumentation was extended, and the resultant forces and their direction were determined for both men and women.

METHODS

A mockup was constructed utilizing measurements obtained on a Convair 240. The handle was mounted in a wall recess of the mockup 52.5 in. above the floor and instrumented with a Dillon dynamometer as in Fig. 1 A. This arrangement was subsequently modified for Series 2 in order to obtain measurements of the horizontal and vertical components of force as well as the resultant and its angle as shown in Fig. 1 B. Three modifications of the simple D ring that were tested are shown in Fig. 2:

A. A 0.3 in. diam steel D ring with a 0.13 in. thick shield approximately 2 in. in height welded to the ring;
B. A 0.3 in. diam steel D ring;
C. A 0.67 in. diam rubber-covered handle.

Only the rubber-covered handle was used in Series 2.

A total of 22 female subjects age 19–34, 9 male subjects age 28–42, and 6 children age 3–13 participated in the tests. Thirteen of the female subjects were drawn from a College of Nursing Physiology class, six were wives of the

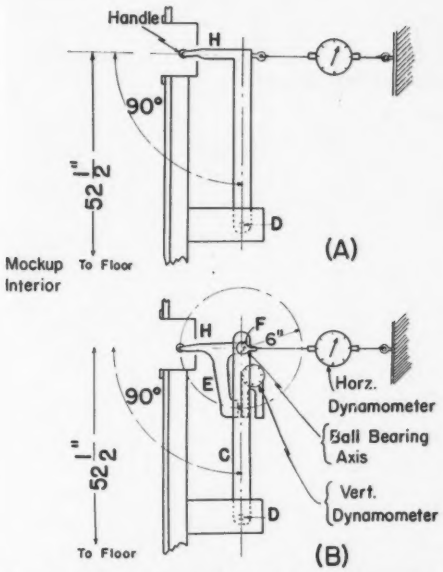


Fig. 1. Emergency exit force measuring apparatus mounted in the mockup wall. (A) Instrumented to measure horizontal force only in Series 1. (B) Instrumented to measure horizontal and vertical force in Series 2.

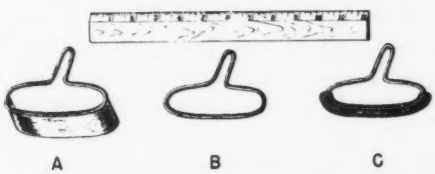


Fig. 2. Sketch of handle configurations. A, Shielded; 0.3 in. diam steel D ring with a 0.13 in. thick steel flange welded to the ring. B, Unprotected; 0.3 in. diam steel D ring. C, Protected; 0.3 in. diam steel D ring covered by rubber to a diameter of 0.67 in.

laboratory staff, and three were airline hostesses. All male subjects were members of the laboratory staff.

Tables I A and I B give anthropometric data and a schedule of the subjects' test participation. In order to minimize the effect of fatigue, subjects were alternately tested at each position, with a maximum of 6 to 8 individual exertions during the half-hour daily sessions.

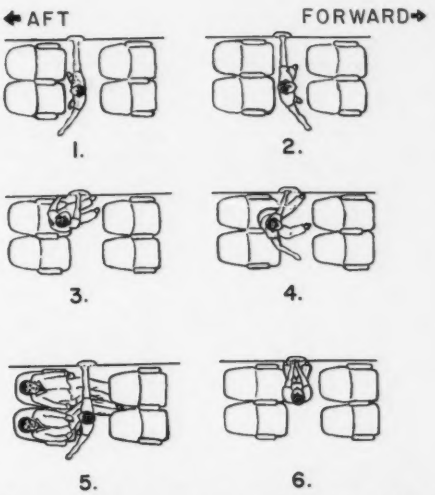


Fig. 3. Typical positions assumed by subjects for the operation of port side emergency exit handles. 1, Standing–right hand. 2, Standing–left hand. 3, Seated–right hand. 4, Seated–left hand. 5, Standing over passengers–right hand, left hand similar to position number 2. 6, Chosen position — occasionally women when offered their choice assumed a standing position and used both hands as illustrated here, but subjects generally reverted to position number 1. Positioning for the operation of starboard exits was essentially the same as illustrated, but with the hands reversed.

The maximum force that the subjects were capable of applying to the D ring during a five-second muscular contraction was determined. All subjects were allowed to initiate the contraction at will. Several observers were stationed outside of the mockup to monitor the instruments and time the contraction, signaling the completion of the five-second interval by an electrically-operated bell mounted inside the mockup. The subjects were positioned as follows:

1. Seated in a passenger type aircraft seat.
2. Standing, with the aircraft seats unoccupied.
3. Standing over passengers, increasing the interference to operation of the exit handles.
4. Subjects' choice of position, method, and use of both hands, if desired.

TABLE 1A

Anthropometric Measurements of Subjects

Subject	*Sex*	*Age (years)*	*Height (in.)*	*Weight (lb.)*	*Anterior arm reach (in.)*	*Sitting height (in.)*
1	F	19	69.0	146	32.5	36.0
2	F	21	71.5	141	33.5	35.5
3	F	19	66.5	139	32.5	33.5
4	F	19	63.0	126	31.0	32.5
5	F	19	66.0	135	29.0	35.0
6	F	20	67.0	115	33.0	34.0
7	F	20	63.0	102	31.5	32.5
8	F	19	63.0	112	32.0	34.5
9	F	20	66.5	162	32.5	34.5
10	F	21	64.5	125	32.0	34.5
11	F	33	65.0	124	30.5	32.5
12	F	29	65.0	151	31.5	34.0
13	F	34	64.0	119	30.5	34.0
14	F	27	63.0	110	29.7	32.0
15	F	26	65.5	145	31.5	33.5
16	F	30	66.0	132	33.5	34.5
17	F	—	—	—	—	—
18	F	—	—	—	—	—
19	F	34	65.0	113	30.5	34.0
20	F	20	64.0	115	28.0	34.5
21	F	21	64.0	118	31.5	34.0
22	F	20	66.0	128	31.0	35.0
23	M	32	70.5	253	34.5	36.5
24	M	30	68.5	121	32.5	35.0
25	M	42	69.0	158	32.5	34.5
26	M	35	70.5	184	32.5	37.0
27	M	36	66.5	154	31.5	34.5
28	M	35	71.5	264	35.0	38.5
29	M	29	74.0	208	36.0	36.5
30	M	28	70.0	191	33.5	35.5
31	M	29	73.0	173	35.5	36.5
32	F	3.5	38.5	33	18.0	22.0
33	M	4	43.0	44	20.0	23.0
34	M	5.5	45.0	47	22.0	25.0
35	M	7	50.5	100	26.5	26.5
36	M	8	53.0	68	29.0	26.5
37	M	13	64.5	116	30.5	32.5

TABLE I B

Schedule of Subjects Participating in Series I and Series II According to Subject Number, Exit Location and Handle Type

Series 1. Horizontal Force

Type handle	*Exit location*	*Subjects participating*
Shielded	Port Starboard	Women 15, 16, 17, 18
Unprotected 0.3 in.	Port	Women 1, 2, 3, 4, 5, 6, 7, 8 ,9, 10, 11, 13, 14, 19, 20, 21, 22
	Starboard	Women 1, 2, 3, 4, 5, 6, 11, 13, 14, 19, 20, 21, 22
Rubber covered 0.67 in.	Port	Women 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, Child — 37
	Starboard	Children 32, 33, 34, 35, 36, 37

Series 2. Resultant Force and Angle

Rubber covered 0.67 in.	Port and starboard exits	Women 11, 12, 13, 14, 15, 16, 17, 18
		Men 23, 24, 25, 26, 27, 28, 29, 30, 31

Fig. 3 shows typical positions assumed by subjects for the operation of port side emergency exit handles.

Jerk forces were determined in the standing position only. This position allowed the subject to utilize a rapid muscular contraction and the acceleration of his body mass.

Tests were confined to the D ring handle since this handle was felt to be the best type of design representing handles that activate release and removal of the emergency exit in one continuous motion.

Handles were essentially isometric. A force of 100 lb produced a handle displacement of less than 0.25 in.

APPARATUS

The measuring apparatus in Fig. 1 A is relatively simple and self-explanatory. The handle H and the dynamometer are oriented in a straight line, the axis D serving only to stabilize the handle. The apparatus in Fig. 1 B is also relatively simple but requires some explanation. The arms H and E are of the same length and rotate around a common axis F. The horizontal dynamometer is attached to this axis, but not directly connected to the arms H and E. The longer arm C rotates about an axis D. A true horizontal force applied to the handle results in a reading on the horizontal dynamometer in proportion to the force applied, with a zero reading registering on the vertical dynamometer. Conversely a true vertical force applied to the exit handle results in the total reading being registered on the vertical dynamometer. At 45° from the horizontal and vertical, the two dynamometers register equal forces.

Static calibrations of the apparatus were obtained by attaching a line to the handle and the floor at a known angle from the mockup wall. Tension was varied by the use of a turnbuckle located in series with the line. Static calibrations indicate a maximum error of 5 lb, and less than one degree angular error with a 100-lb tension. Above 100 lb the rate of error accumulation is rapidly reduced as the slack in the system and stretch of the cable diminish.

RESULTS

Maximum forces applied by women to unprotected and rubber-covered handles are compared in Table II A of Series 1. The mean maximum force using the rubber-covered handle exceeded the values for the unprotected handle by approximately 19%. Values for the ten women subjects who completed both series of pulls with

the rubber-covered and unprotected handles were matched and the difference found to be statistically significant. The reduced voluntary strength measurements obtained with the unprotected handle may be explained by the subjects' complaint of pain and moderate trauma to the hand as a result of maximum effort.

A few initial tests of the shielded D ring shown in Fig. 2 A indicated that it was not subjectively acceptable by the individuals participating in the experiment. The mean maximum forces developed by four of the above female subjects for all positions were 18% lower than with identical tests using the unprotected D ring, Fig. 2 B.

Individual data obtained in these few preliminary tests are not presented, but the over-all mean maximum sustained forces applied in the operation of the shielded and 0.3 in. unprotected handle were 43 and 50 lb respectively.

TABLE II A

Series 1. Comparison of the Individual Maximum Forces (lb) Applied by Women Subjects to a 0.67 in. Rubber-Covered D Ring and a 0.3 in. Diam Unprotected Steel D Ring Mounted in the Port Exit Identical Subjects N = 10

0.67 in. Rubber-Covered D Ring

Subject No.	*Seated *(5 sec)*		*Standing *(5 sec)*		*Standing over passengers *(5 sec)*		*Choice *(5 sec)*	*Jerk (standing) *(0.2–0.3 sec)*	
	Left	*Right*	*Left*	*Right*	*Left*	*Right*		*Left*	*Right*
1	77	90	92	100	85	90	95	184	200
2	75	76	120	110	120	108	120	264	316
3	60	88	100	115	50	80	95	130	168
4	75	83	85	110	80	105	145	165	170
5	52	73	70	63	65	60	60	108	73
6	62	55	33	42	45	52	48	75	111
7	30	47	48	51	57	47	48	106	175
8	17	35	32	45	33	37	53	143	133
9	40	67	75	82	73	62	80	142	165
10	39	72	62	46	63	50	55	118	168
Mean	53	69	72	76	67	69	80	143	168
0.3 in. Diam Steel D Ring (from Column 2, Table III)									
1	47	45	45	55	60	50	65	118	140
2	52	65	70	110	50	90	125	230	280
3	15	37	55	55	66	55	85	73	170
4	26	57	78	87	92	100	147	145	175
5	57	68	50	61	52	46	41	73	68
6	52	50	49	50	41	45	37	71	70
7	36	52	32	41	47	40	47	100	161
8	33	27	44	49	46	55	48	92	121
9	66	70	60	59	58	64	76	135	112
10	46	50	50	48	30	48	57	92	100
Mean	43	52	53	62	54	59	73	113	140

* Duration of muscular contraction.

TABLE II B

Series 1. Comparison of the Individual Maximum Forces (lb) Applied by Women Subjects to a 0.3 in. Diam Unprotected D Ring Mounted in the Port and Starboard Exits

Starboard Exit

Subject No.	*Seated* *(5 sec)*		*Standing* *(5 sec)*		*Standing over passengers* *(5 sec)*		*Choice* *(5 sec)*	*Jerk (standing)* *(0.2–0.3 sec)*	
	Left	*Right*	*Left*	*Right*	*Left*	*Right*		*Left*	*Right*
1	50	58	70	80	50	75	75	120	115
2	77	63	97	126	80	105	142	264	300
3	63	65	60	80	68	60	80	92	80
4	80	80	95	105	85	100	115	170	203
5	34	48	47	60	50	46	54	106	138
6	24	16	32	32	27	30	54	88	118
11	35	47	55	65	50	50	22	163	145
13	32	40	25	25	20	30	10†	123	193
14	30	45	60	47	63	47	8†	146	197
19	29	45	31	23	45	25	37	196	235
20	43	47	43	65	47	70	60	67	104
21	25	38	35	52	47	44	55	115	128
22	35	27	40	45	34	35	41	110	110
Mean	43	48	53	62	51	55	$N=11$ 67	135	159

Port Exit

1	47	45	45	55	60	50	65	118	140
2	52	65	70	110	50	90	125	230	280
3	15	37	55	55	66	55	85	73	170
4	26	57	78	87	92	100	147	145	175
5	57	68	50	61	52	46	41	73	68
6	52	50	49	50	41	45	37	71	70
7	36	52	32	41	47	40	47	100	161
8	33	27	44	49	46	55	48	92	121
9	66	70	60	59	58	64	76	135	112
10	46	50	50	48	30	48	57	92	100
11	32	32	42	55	38	42	75	108	197
13	40	37	30	40	37	43	25	180	132
14	50	45	42	41	45	47	40	104	149
19	49	25	23	35	45	55	43	207	245
20	48	35	46	25	45	35	46	93	90
21	60	54	55	45	35	45	47	131	130
22	36	36	52	44	42	37	46	115	107
Mean	44	46	48	53	49	53	62	122	144

* Duration of muscular contraction.
† Handle inadvertently adjusted to allow it to contact stops.

TABLE III

Comparison of the Mean Maximum Force Applied by Women to the 0.3 in. Unprotected and the 0.67 in. Diam Rubber-Covered Handles Mounted in the Port Exit. Subjects Number 1 through 10. Identical Subjects. Q_1 = 25th Percentile. Q_3 = 75th Percentile. N = 10.

Unprotected Handle

Position and duration of muscular contraction	*Right hand*					*Left hand*				
	Mean	*Median*	*Range*	Q_1	Q_3	*Mean*	*Median*	*Range*	Q_1	Q_3
Seated 5 sec	52	51	27–70	41	66.5	43	46.5	15–66	29.5	54.5
Standing 5 sec	62	55	41–110	48.5	74	53	50	32–78	44.5	65
Standing over passenger 5 sec	59	52.5	40–100	45.5	77	54	51	30–92	43.5	63
Jerk 0.2–0.3 sec	140	130.5	68–280	85	172.5	113	96	71–230	73	140

	Right, left or both hands				
	Mean	*Median*	*Range*	Q_1	Q_3
Choice 5 sec	73	60.5	37–147	44	105

Rubber-Covered Handle

Position and duration of muscular contraction	*Right hand*					*Left hand*				
	Mean	*Median*	*Range*	Q_1	Q_3	*Mean*	*Median*	*Range*	Q_1	Q_3
Seated 5 sec	69	72.5	35–90	51	85.5	53	56	17–77	34	75
Standing 5 sec	76	72.5	42–115	45.5	110	72	72.5	32–120	40.5	96
Standing over passenger 5 sec	69	61	37–108	48.5	97.5	67	64	33–120	47.5	82.5
Jerk 0.2–0.3 sec	168	168	73–316	122	187.5	143	136	75–264	107	174.5

	Right, left or both hands				
	Mean	*Median*	*Range*	Q_1	Q_3
Choice 5 sec	80	70	48–145	50.5	107.5

The averages for snap or jerk force operation of the shielded and the 0.3 in. unprotected handle were 88 and 113 lb.

The shielded handle does not allow the hand to fully grasp the handle, concentrating the tension of the pull in the musculature of the fingers. This handle was eliminated from subsequent tests.

The difference between the left hand and right hand forces exerted by women subjects in Table II B is shown. When a jerking force was applied to the unprotected handle mounted in the starboard exit, the difference was significant. In the case of the port exit the difference was significant only at the 0.10 level. However, in both instances the two hands were significantly correlated with correlation coefficients of 0.77 and 0.91 calculated for the port and starboard exits.

Apparently in these tests the seat back directly in front of the exit operating area does not interfere appreciably with the subjects' operation of the exit when facing in the fore or aft direction as illustrated in Fig. 3. A forty-inch seat spacing was utilized in these tests. With reduced seat spacing and variation in seating with refer-

ence to the exit location as required in higher density aircraft loading, it is probable that increased interference to exit operation would result.

The rubber-covered handle enabled the subjects to attain their highest maximum values. A comparison of the mean, medians, and percentile of women subjects using the unprotected and rubber-covered handles is given in Table III. Mean maximum forces were higher with the right than with the left hand. However, deviations were large and the number of subjects low ($N=10$). Statistical analysis indicated this difference to be nonsignificant.

Results with children in Series I were not conclusive. Several attempts were made to measure the force that children are capable of applying to emergency exit handles. The data obtained are insufficient in number and exceedingly variable.

Smaller children were unable to produce reliable and consistent sustained muscular contractions of five-second duration, but rather when seriously attempting to do so were actually applying a succession of jerking motions. Of the children participating in the tests only the oldest, a thirteen-year-old boy completed the full series of sustained pulls. The sustained force that he applied to the handles was about 26 lb less than the mean value for women subjects. However, he applied a jerking force of from 3 lb less to 21 lb greater than the mean value obtained for women. It was difficult to produce and assess motivation in this group. The maximums of several jerking force measurements for children are listed in Table IV.

Using the apparatus in Fig. 1 B repeat tests on adults were conducted with the rubber-covered handle in order to obtain resultant forces and angles. A graphic representation of the mean maximum resultant forces and angles are illustrated in Figs. 4 and 5.

By pooling Series 1 data for left and right hand operation of the protected handle mounted in the port exit it was found that the mean maximum force of 155 lb applied by women during short duration jerking force measurements in Table II A was 2.1 times similar five-second duration muscular contractions of 74 lb in the standing position.

TABLE IV

Series 1. Maximum Jerking Force Applied by Children to the Rubber-Covered 0.67 in. Diam D Handle. Maximum of Several Attempts Allowing Choice of Position and Hands Used

Subject age	*Sex*	*Jerking force (lb)*
3	F	4
4	M	45
5	M	40
7	M	68
8	M	89
13	M	215

Similar pooling of Series 2 data on men for both exits indicated the mean short duration force of 329 lb in Table VI to be 2.5 times the equivalent five-second muscular contraction of 134 lb. Motion picture frame counts were made in order to determine the duration of the jerking action. From the initiation of body acceleration to relaxation of muscular contraction, the duration of the jerking action was found to approximate 0.2 to 0.3 sec.

It was anticipated that the inertial application of the body mass in the jerking action would be positively correlated with the force applied. Analysis of pooled data (left and right hands, port and starboard exits) for the nine male subjects in Table VI yielded a very low correlation coefficient of 0.08. From a similar analysis of the right-handed jerking force to the port exit available on nine women in Table II B, a low correlation coefficient of 0.27 was obtained. In these tests body weight does not appear to be significantly correlated with force.

Maximum jerk forces appear to be limited not so much by the ability of the subject to accelerate his body, but by his gripping strength and tolerance of the local high pressure transmitted to the hand.

A highly positive correlation between the subjects' height and the angle of the force applied to the exit handle was expected. Analysis

TABLE V

Series 2. Individual Maximum Forces (lb) Applied by Women Subjects to a 0.67 in. Rubber-Covered D Ring. Calculated Resultant Forces and Angles Derived from the Measurements Obtained with the Dynamometers Arranged to Indicate Horizontal and Vertical Forces. Five-Second Muscular Contractions. θ = Resultant Angle Down from the Horizontal.

Starboard Exit

Subject No.	*Force components*	*Seated *(5 sec)*		*Standing *(5 sec)*		*Standing over passengers *(5 sec)*		*Choice *(5 sec)*
		Left	*Right*	*Left*	*Right*	*Left*	*Right*	
11	Resultant	63	85	57	54	56	94	87
	θ	61°	62°	24°	34°	22°	28°	35°
12	Resultant	54	49	79	74	73	94	136
	θ	48°	35°	21°	8°	24°	20°	17°
13	Resultant	45	54	45	46	38	38	67
	θ	56°	56°	27°	30°	15°	23°	22°
14	Resultant	64	90	72	64	73	57	75
	θ	51°	57°	11°	9°	12°	14°	12°
15	Resultant	28	45	47	47	43	63	31
	θ	57°	69°	12°	12°	13°	28°	17°
16	Resultant	83	82	46	51	74	55	68
	θ	57°	58°	19°	8°	22°	6°	24°
17	Resultant	21	30	48	35	46	32	50
	θ	47°	57°	6°	0°	4°	5°	6°
18	Resultant	25	53	18	24	31	28	31
	θ	66°	71°	12°	7°	22°	45°	36°
Mean resultant force		48	61	52	49	54	58	68
Mean resultant angle		55°	58°	16°	14°	17°	21°	21°

Port Exit

11	Resultant	99	115	67	63	82	62	72
	θ	59°	56°	27°	17°	24°	29°	24°
12	Resultant	81	88	86	117	49	61	137
	θ	54°	47°	7°	10°	28°	11°	8°
13	Resultant	76	66	57	61	42	54	66
	θ	53°	50°	11°	11°	18°	17°	18°
14	Resultant	96	98	81	86	89	70	91
	θ	47°	52°	18°	22°	16°	21°	14°
15	Resultant	49	38	28	28	35	56	56
	θ	72°	72°	0°	0°	25°	30°	9°
16	Resultant	71	72	50	47	47	60	56
	θ	51°	49°	17°	6°	19°	24°	12°
17	Resultant	46	24	50	42	52	48	56
	θ	68°	75°	0°	0°	5°	12°	31°
18	Resultant	52	42	25	29	26	27	41
	θ	75°	73°	0°	0°	23°	27°	29°
Mean resultant force		70	68	56	59	53	55	72
Mean resultant angle		60°	59°	10°	8°	20°	21°	18°

* Duration of muscular contraction.

TABLE VI

Series 2. Individual Maximum Forces (lb) Applied by Male Subjects to a 0.67 in. Rubber-Covered D Ring. Calculated Resultant Forces and Angles Derived from the Measurements Obtained with the Dynamometer Arranged to Indicate Horizontal and Vertical Forces. Resultant Force in lbs, θ = Resultant Angle down from the Horizontal.

Starboard Exit

Subject No.	*Force components*	*Seated *(5 sec)*		*Standing *(5 sec)*		*Standing over passengers *(5 sec)*		*Choice *(5 sec)*	*Jerk (standing) *(0.2–0.3 sec)*	
		Left	*Right*	*Left*	*Right*	*Left*	*Right*		*Left*	*Right*
23	Resultant	154	208	137	185	145	168	147	215	312
	θ	44°	46°	10°	16°	24°	17°	18°	3°	6°
24	Resultant	39	49	59	27	51	32	38	250	271
	θ	50°	44°	20°	22°	9°	20°	23°	0°	5°
25	Resultant	142	158	230	217	109	121	245	400	353
	θ	48°	55°	27°	23°	8°	13°	39°	9°	7°
26	Resultant	83	117	90	95	86	95	107	271	357
	θ	33°	36°	27°	22°	22°	18°	23°	24°	2°
27	Resultant	82	134	81	120	73	114	99	437	457
	θ	47°	54°	30°	16°	16°	22°	31°	5°	2°
28	Resultant	127	178	125	145	130	155	155	406	334
	θ	34°	32°	2°	18°	1°	14°	2°	5°	13°
29	Resultant	95	150	126	138	128	140	181	182	282
	θ	18°	33°	7°	11°	11°	5°	14°	8°	6°
30	Resultant	150	153	150	187	120	88	200	230	265
	θ	50°	52°	5°	8°	10°	13°	1°	4°	11°
31	Resultant	137	135	164	170	118	135	204	426	391
	θ	31°	22°	12°	9°	7°	15°	22°	4°	4°
Mean resultant force		112	142	129	143	107	116	152	313	336
Mean resultant angle		39°	42°	16°	16°	12°	15°	19°	7°	6°
				Port Exit						
23	Resultant	170	135	125	162	98	107	153	310	315
	θ	45°	48°	16°	20°	15°	8°	11°	0°	0°
24	Resultant	75	61	39	55	32	46	31	286	183
	θ	53°	35°	25°	3°	20°	10°	17°	7°	10°
25	Resultant	188	184	182	204	138	163	271	336	398
	θ	54°	51°	23°	25°	13°	11°	28°	20°	26°
26	Resultant	127	103	109	112	125	104	170	223	305
	θ	48°	34°	26°	29°	16°	13°	14°	13°	10°
27	Resultant	102	88	86	65	99	62	95	411	470
	θ	56°	60°	14°	23°	19°	14°	32°	10°	15°
28	Resultant	139	193	140	186	132	164	170	466	530
	θ	34°	37°	40°	6°	4°	12°	2°	9°	11°
29	Resultant	149	187	100	175	125	130	248	276	260
	θ	43°	53°	0°	3°	0°	0°	22°	17°	21°
30	Resultant	156	183	155	202	111	130	155	231	246
	θ	50°	43°	0°	7°	5°	4°	0°	4°	6°
31	Resultant	133	167	140	138	137	133	135	372	390
	θ	56°	54°	15°	0°	8°	2°	4°	8°	15°
Mean resultant force		138	144	119	144	111	115	158	323	344
Mean resultant angle		49°	46°	14°	13°	11°	8°	14°	10°	13°

* Duration of muscular contraction.

of pooled data (left and right hand, port and starboard exits) for nine male subjects in the standing position yielded a nonsignificant correlation coefficient of 0.52. A study of motion pictures taken during the course of the tests indicated a tall individual may crouch considerably during the operation of an exit handle, whereas a shorter individual may stand relatively straight.

DISCUSSION

It would be practically impossible to simulate all of the mechanical, environmental, and emotional conditions of an actual emergency evacuation. Motivation in an actual emergency situation would probably be considerably greater. The emotional excitement and resulting increased adrenomedullary activity in an actual survival situation would tend to increase muscular strength as compared to a simulated condition. In order to approach as closely as possible forces that might be exerted in an emergency situation, the tests were conducted on a group and individual competitive basis with emphasis on the individual competing with himself.

Operation of emergency exit handles involve a complex interaction of numerous muscle groups. The action of each individual muscle group cannot be conveniently isolated, but for applied purposes the system as a whole may be evaluated. In order to produce accurate simulated working areas, detailed attention was given to duplicating interferences to exit operation, such as seat spacing, passenger seating, and baggage rack configuration and clearances.

Since the number of subjects participating in the tests was relatively small, efforts were made to acquire a wide distribution of body height and weight as shown in Table I. Because of the small sample size the results in Table III are presented in the form of a quartile distribution in order to indicate the extent and direction of the probability curve skewness.

The S-9 Committee of the SAE and this laboratory were interested in the maximum forces that would be expected in the operation of various types of exit handles in order to provide criteria for the establishment of recommended

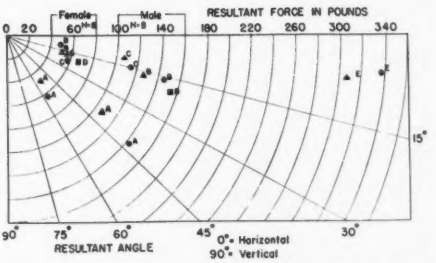


Fig. 4. Mean maximum forces applied to the right (starboard) emergency exit handle. Magnitude of force expressed outward from the center. Resultant angle of force expressed downward from the horizontal. Female subjects number 11 through 18 (N = 8); male subjects, 23 through 31 (N = 9). ●, right hand; ▲, left hand; ■, choice — or right. A — Seated; B — Standing; C — Standing over passengers; D — Subjects' choice of position and method; E — Standing — jerking force (male only).

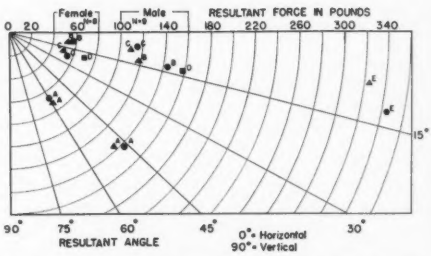


Fig. 5. Mean maximum forces applied to the left (port) emergency exit handle. Magnitude of force expressed outward from the center. Resultant angle of force expressed downward from the horizontal. Female subjects number 11 through 18 (N = 8); male subjects, 23 through 31 (N = 9). ●, right hand; ▲, left hand; ■, choice–left or right. A — Seated; B — Standing; C — Standing over passengers; D — Subjects' choice of position and method; E — Standing — jerking force (male only).

practices and design standards as related to structural reliability and operation of exits. In addition, a knowledge of the minimum–maximum force applied by subjects is of interest in order to establish a crude range of the subjects' force capability. Further work should be undertaken in order to establish the magnitude of what might be called a "comfortable force" of exit

operation. The term "comfortable," however, is subjectively evaluated and may be interpreted differently by various individuals.

Aircraft may come to rest in various attitudes following a crash and in more severe cases the equipment in the cabin dislodged and deformed. The effect of these factors upon the subjects' capability to operate emergency exits should be considered for investigation.

A determination of the capability of children to operate emergency exits was attempted in order to evaluate the possibility of unauthorized or inadvertent operation of exits. The need for this information has been emphasized by an instance of an inadvertent in-flight exit release and the loss of a three-year-old child engaged in playing with the emergency exit release handle. This problem has been reduced considerably by the design of plug type exits for pressurized aircraft. Results with children were inconclusive, and for reliability require additional measurements. However, measurements of the maximum forces obtained under the most advantageous conditions are included in order to illustrate the approximate magnitude of the stepwise increase in strength with age.

A different kind of accident involved emergency exits that would not open or were extremely difficult to open. During attempts to evacuate the aircraft, handles were broken loose from two of the emergency exits. Meanwhile, passengers and the hostess were attempting to operate an outward opening main cabin door by pulling inward. There was no fire. Had a fire occurred, the delay in evacuation would have resulted in a number of casualties. Incidents of this type indicate that better structural design and maintenance may be needed. Emergency exit handles should be of sufficient structural strength to preclude structural failure within the limits of human force capability.

Determination of the maximum forces that may be applied to emergency exit release mechanisms provide the design engineer with a base line index of the magnitude and the direction of forces that may be expected under various conditions. An additional margin of safety and structural reliability should be added to the measurements obtained under simulated conditions.

Acknowledgment

The authors wish to acknowledge the advice and encouragement of Dr. Barry G. King, who contributed much of his time and energy to working with this laboratory and the S-9 Committee of the SAE.

REFERENCES

1. McFADDEN, E., and SWEARINGEN, J. J., Forces that may be exerted by man in the operation of aircraft door handles. *Human Factors*, 1, 16, 1958.

Human Factors Research on Weapon Systems Project Teams[1]

FREDERICK A. MUCKLER, Human Factors Specialist, The Martin Company, Baltimore, Maryland.

The research role of the human factors specialist on weapon systems project teams has been the subject of misunderstanding. Bound by other project roles, time limitations, complexity of phenomena, inadequate methodology and facilities, human factors project research has often left much to be desired. If effective project research is to be accomplished, there is a need for the development of (1) *generalized research and development tools and* (2) *specific and detailed criteria for research methodology for the test and evaluation of complex man–machine weapon systems.*

RESEARCH AND THE PROJECT SPECIALIST

The research role of the human factors specialist on weapon systems project teams has been the subject of misunderstanding by human factors specialists outside the industrial setting. Contrary to many opinions, in the customary team operation the human factors specialist has very little time for research activities. Among a number of roles, his major effort lies in providing human factors design criteria for his engineering associates. Wood[8] states this quite plainly:

> ". . . the human factors engineer has the same responsibility as any other engineer. An engineering department's primary job is to design and/or develop some system, component thereof, or other equipment. The engineer's job is to apply information in his particular area of specialization to the solution of some practical problem involved in the design of that equipment. The human factors engineer has the job of applying information about human behavior to the solution of the design problem in question."

As a matter of fact, the project human factors specialist has a number of practical roles; Kraft[3] summarizes this nicely:

> "The industrial human engineer may wear many hats — he may be a scientist in one situation, an expertizer in another, a practical engineer in a third, an information specialist in a fourth, and a salesman in still another."

Fulfilling these many roles under the usual conditions of time limitations and restrictions on personnel, funds, and facilities often makes effective human factors research programs extremely difficult if not impossible.

OBJECTIVES OF PROJECT RESEARCH

The nature and objectives of project research have also been consistently confused even by human factors specialists closely connected with weapon systems development teams. Project research is applied research, usually in the strictest sense of that adjective. It is not — as someone said — "an excuse for the study of one's favorite variables," but it is research designed to answer some specific project problem for which available data are not adequate and where the project problem is of sufficient importance that an expert judgement — or "guess" if you will — is not sufficient. Kraft[3] has listed a number of criteria for information that is supplied to project design by human factors specialists; these criteria apply as well to research information which:

> "(a) must be appropriate to the problem at hand;

[1] This report is based on a presentation given at the Annual Meeting of the Midwestern Psychological Association as part of a Symposium on Human Factors in the design of Weapon Systems, held 9 May 1959. This work was supported in part by the United States Air Force under Contract No. AF 33(616)-5472 monitored by Aero Medical Laboratory, Directorate of Laboratories, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

(b) should consider the entire systems requirement;
(c) must be presented in an understandable manner to the user;
(d) should be quantitative, when possible;
(e) should be consistent with the over-all design requirements; and
(f) should be feasible for subsequent production, sales, operation, and maintenance."

The applications emphasis of these criteria is apparent. It should be understood that the project objective is to provide the best weapon system in the quickest possible time at the lowest possible cost. The objective is not to provide basic information about human behavior or for that matter about any other phenomena underlying the weapon system. Indeed, since research is usually time consuming and costly, the ideal situation from the point of view of project management would be that sufficient data are already available for the weapon system and thus no research is required at all.

LIMITATIONS OF PROJECT RESEARCH

This ideal, however, is seldom met; research is frequently necessary as a part of weapon systems development. The question is, "How can human factors project research be conducted to provide timely and reliable information?" The answer to this question must take into account the fact that project information requirements often impose severe handicaps on effective research. Two of the many problems in this context can stand specific comment.

Timeliness of Information

First, the timeliness of research information is a paramount factor that is often overlooked. Perhaps the most important contributions of the human factors specialist are made in the early stages of design and development. During these stages the basic concepts of the system are being established, and the human factors specialist can strongly influence the direction these concepts take. But typically during early phases of system development, design concepts may change rapidly. To influence the direction of these changes information must be available at the time. In the case where the information is derived from research this time objective is obviously often impossible. Further, due to basic design changes, the human factors problem for which a research program is generated may no longer exist by the time the research program has been completed and the information is made available.

Complexity of Research Phenomena

Second, one of the most interesting aspects of any weapon system is the complexity of the man–machine relationships involved in the operation of the system. Even the most casual examination of the mission and task analyses of current weapon systems and the equipment provided for the human operator of these systems demonstrates the many roles of the operator and the many detailed interactions with the system which he must assume. And these interactions are by no means trivial since they frequently can determine the ultimate success or failure of the total system. The human factors specialist never has to look for research problems; in fact, his major task is to select the most important of the many problems for which he must find solutions. Often his selection will center on the most complex man–machine interactions since these are often the most important and he seldom has sufficient available data.

Developing Methodology and Facilities

However, given a complex system problem, the human factors specialist in initiating a project research program must often first generate the research methodology for properly attacking the problem. This in itself may be a creative task of some magnitude. Further, most human factors groups are new to weapon systems project teams, research facilities are often nonexistent, and the human factors specialist must often establish research facilities and equipment where either such facilities are nonexistent and/or the

need for research facilities is not clearly understood by project management. If the research problem is a complex one, it may, in addition, require very extensive facilities and equipment which inevitably means a considerable expenditure of funds and manpower. For example, many of the most important problems in the design of manned flight vehicles center around the role of the human operator in the guidance and control of the vehicle. Adequate information in this context can often be gained only through full flight simulator studies; the cost of flight simulators for design purposes can mean the expenditure of hundreds of thousands of dollars.

The "Quick and Dirty" Study

Under all these conditions (and of course many others), it is not surprising that many human factors project research programs leave a great deal to be desired. At worst, they are not only "quick and dirty" but they can be "quick and very dirty." In our opinion, a great deal more confidence can be placed in extrapolation from known data by a competent human factors specialist than in the results of poorly planned and hastily executed project research studies. The classical requirements of proper experimental control and experimental design still apply to the most applied experimental program as well as to the most basic study. If these conditions cannot be reasonably met, it is questionable that project research should be attempted at all.

SUBCONTRACTING PROJECT RESEARCH

Indeed, some competent authorities have felt, with considerable justification, that human factors project team specialists should not participate in project research programs.[7] It is true that if research information is needed, sources outside the immediate project structure may be used:

1. Effective coordination with in-service laboratories is often an answer to project research needs. Many of these laboratories (e.g., Wright Air Development Center, the School of Aviation Medicine, etc.) have facilities which are available. However, these laboratories often have their own research projects underway and they must service many project activities. Research time must be limited to the most important research problems and the weapon systems with highest priority.

2. Research subcontracting with university laboratories is another avenue to fulfilling project research needs. Some of the most effective systems research has been conducted at university facilities; the work on air traffic control in the facilities of the Aviation Psychology Laboratory at Ohio State University is an outstanding example.[2] Often, however, university laboratories neither have the facilities nor — and this is perhaps most important — the inclination to perform highly applied project research.

EFFECTIVE HUMAN FACTORS PROJECT RESEARCH

Despite the pessimistic tenor of the preceding comments, it is believed that effective and timely project human factors research can be performed by human factors specialists on the project team. The work of Tillinghast and Henderson[6] in the development of the cockpit display requirements for the Ryan X-13 VTOL aircraft is an excellent example of what can be done. Future human factors project research will depend however, in our opinion at least, on future developments in two areas:

1. We need generalized research and development tools. This is particularly true with respect to part-task devices such as, for example, radar simulators, anthropometric work space layouts, flexible tracking devices, and the like. These are research devices which can be obtained at reasonable expense and with a minimum requirement for continued maintenance. With these tools available and with additional fabrication facilities the human factors specialist has some hope of generating meaningful research information within project time limitations.

2. More important, there is a need for specific and detailed criteria on research methodology for the test and evaluation of complex man-machine systems. One of the major problems in this connection is measurement. The conventional performance indices for human behavior are often not compatible with engineering descriptions and analytic techniques. Pioneering work along these lines has already been reported by, among others, Birmingham and Taylor,[1] Lindquist and Gross,[4] and McRuer and Krendel,[5] but a great deal more must be accomplished before these techniques become standard project methods.

The human factors project team member has neither the time nor the inclination to develop research tools and research methodology for his pressing project technical problems. But given the methodology and the tools, he should be able to make a great deal more effective *research* contribution to weapon systems development from the human factors point of view.

Many who have served as human factors project specialists have made, by necessity, a host of judgements — or "guesses" — on specific human factors problems connected with system design. These judgements are too often guesses, but human factors design criteria must be supplied. Decision will be made concerning human factors technical problems; if human factors specialists do not make these decisions they will be made elsewhere. Most human factors specialists would rather base technical criteria on valid, reliable, and pertinent research findings. There is a strong hope that considerably more human factors research will be done on weapon systems projects in the future. However, an increase in future human factors project research will probably rest upon an increasing demonstration that such research can contribute directly and effectively to weapon systems design.

REFERENCES

1. Birmingham, H. P., and Taylor, F. V., A human engineering approach to the design of man-operated continuous control systems. USN, Naval Research Laboratory, NRL Report No. 4333, 1954.

2. Fitts, P. M., Schipper, L., Kidd, J. E., Shelly, M., and Kraft, C., Some concepts and methods for the conduct of system research in a laboratory setting. In "Symposium on Air Force Human Engineering, Personnel, and Training Research," G. Finch and F. Cameron (Eds.), pp. 174–187. Washington: National Academy of Sciences — National Research Council, Publication 516, 1958.

3. Kraft, J. A., Industrial approaches to human engineering in America. *Ergonomics*, **1**(4), 301. 1958.

4. Lindquist, O. H., and Gross, R. L., Human engineering man–machine study of a weapon system. Minneapolis: Minneapolis-Honeywell Regulator Co., Aeronautical Division, MH Aero Report R-ED 6094, October 1958.

5. McRuer, D. T., and Krendel, E. S., Dynamic response of human operators. *USAF, WADC Tech. Rep.*, No. 56–524, 1957.

6. Tillinghast, N. W., and Henderson, B. E., A study of cockpit display requirements for VTOL airplanes. *USAF, WADC Tech Rep.*, No. 58–58, 1958.

7. Wissel, J. W., and Hall, S. A., Human engineering research — who should do it and why. *Amer. Psychol.*, **12**(2), 92, 1957.

8. Wood, C. C., Human factors engineering: An aircraft company chief engineer's viewpoint. *Ergonomics*, **1**(4), 294, 1958.

A Marginal Punched Card System for Human Factors Literature

CAROL S. EVANS, Human Factors Group, Douglas Aircraft Company, Inc., Santa Monica, California.

This article describes the marginal punched card bibliographic system used by the Human Factors Group at Douglas Aircraft Company, Santa Monica, California.

The need for such a system, its development, and its merits are discussed.

INTRODUCTION

Fifteen years ago, when the field of human factors was largely undefined, unnamed, and unmanned, the Douglas Company began collecting literature pertinent to human factors problems. The files grew slowly into a collection of clippings, books, reports, memoranda, and journals containing information from the sciences of physiology, psychology, medicine, mathematics, physics, and a variety of other fields The problem of investigators now called human factors personnel was to distill from this literature, usually academic in nature, information pertinent to practical design problems of the aircraft industry, to store this information, and to make it available when needed in a form that engineers could use. The design problems ranged over a wide field — acoustics, cabin decompression, control panel layouts, crash safety, illumination, seating, and vibration, to name a few.

The marginal punched card bibliographic system used by the Human Factors Group was adopted after it was determined that no existing classification method was useful for this particular design-oriented approach.

From 1949 to 1955 several standard filing systems had been tried. Filing reference cards alphabetically by author made a neat, convenient file for input, but proved inadequate for information retrieval. Early attempts to use such classification schemes as the Dewey Decimal System, the Library of Congress system, the Acoustical Society of America system, and Physics Abstracts were unsuccessful for the two fields of acoustics and seating. The system which developed into the present ASTIA system was found inadequate. Methods used by the Naval Electronics Laboratory, Documentation, Inc., and others were examined, but no one system seemed adequate for design purposes.

In 1953 a standard multiple-card file system was initiated, consisting of subject and author files. Reference cards were arranged alphabetically by subject under the subheadings of one of ten major fields of interest. There were many drawbacks to this method of classification. The cards had to be properly filed and kept in order, a task both tedious and time-consuming. There was the problem of selecting appropriate file-card titles, and confusion grew in this respect as personnel changed. A cumbersome number of file cards were needed for adequate cross referencing. The system was relatively inflexible, as it was hard to rework the basic framework to accommodate new areas of interest.

Perhaps the greatest handicap was that many references could not be easily categorized, and, on the other hand, many could logically be filed under several categories. Successful use of the system depended a good deal on the searcher's memory. Source materials such as magazine or journal clippings had an animistic proclivity for hiding under a subheading in one category just when they could be helpful in solving a design problem in another category. Crash safety, for example, is one major field of interest in aircraft, but articles on acceleration, vision, anthropometry, and respiration (especially oxygen systems) often contain important information helpful in making a safety analysis.

In 1955, the decision was made to design a filing system, using punched cards, to meet the

specific needs of the Human Factors Group and to allow for growth over at least a ten-year period.

The basic system now used by the Human Factors Group, as described in this paper, was adapted from the SAMPE[1] system used by the Process Laboratories of the Douglas Aircraft Company and by other companies.

ESTABLISHMENT OF THE SYSTEM

The first step in establishing the punched card system was to decide what was to be coded. Past experience simplified this procedure. A list of twenty-six major subjects was drawn up. It included the fields which the Human Factors Group had dealt with in the past and those which could be expected to become important in the future. The major subject list and the code letters for the major subjects are shown in Table I. The code letters are arbitrary. These are used as abbreviations, and also reduce confusion with the many numbers on the card.

The second step was the compilation of a basic glossary to cover the terminology of the major subjects as it applied to aircraft design and the human factors field. A conscious effort was made to incorporate the vocabularies and patterns of thinking of both engineering and life science personnel. This led to a somewhat redundant system, but one which could be used readily with little preparation. The vocabulary reflects the several disciplines and personal quirks represented by the users. Terms were collected by examination of indices, by scanning bibliographies and books, and by mental gymnastics on the part of the members of the Human Factors Group. Each word or phrase was typed on a small card, arranged alphabetically, reviewed to eliminate duplicates or synonyms, and assigned a code number. These words became the Detail Subject Index. Excerpts of the Index are shown in Table II. The present Detail Subject Index contains approximately 2500 words or phrases.

These terms serve as cross references and as aids in locating material. Many detail subjects

TABLE I

Major Subject List and Code Letters

Code	Major Subjects
AT	Acceleration and tumbling
AC	Acoustics (physical)
AE	Air evacuation and transportation
AW	Arrangement of workspace
*XA	Auditory presentation of information
BI	Bibliographies
CL	Clothing and protective equipment
CO	Controls
CR	Crash studies and safety
*DS	Decompression sickness
EF	Environmental factors
XD	Escape
G	General considerations
HE	Hearing
BD	Human body dimensions (anthropometry)
*XF	Instrumentation
KI	Kinesiology (dynamic anthropometry
MT	Mathematical techniques
MS	Motion sickness
PH	Physiology
PS	Psychology
RB	Radiation biology
RE	Respiration
SA	Sanitation
SE	Seating and berths
*XC	Simulators and training aids
SU	Survival
*XE	Toxicity
*XB	Vestibular phenomena
VB	Vibration, gusts, and buffeting
VS	Vision
VP	Visual presentation of information

* Have been added since the original list was compiled.

TABLE II

Excerpts from Detail Subject Index

B

42–52–65	Back support
36–40–41	Backache
20–24–62	Background lighting
44–46–57	Backward
25–51–64	Bacteria
16–25–30	Bailout
11–49–65	Bailout bottles
33–40–42	Balance
38–49–56	Balance, acid-base, pH
16–67–69	Balance, water
48–56–83	Ballistocardiograph
27–46–47	Balloon
20–47–57	Band-width
36–40–54	Barany chair
34–53–64	Barometric pressure
42–56–57	Barotitis media
26–40–45	Bartley effect
42–52–64	Basal metabolic rate
40–42–51	Battle conditions
12–36–47	Bear
11–27–55	Beat frequency oscillator
24–49–53	Beats
16–17–40	Behavior
22–52–59	Behavior decrement
14–42–46	Bends
41–47–66	Berths
17–40–45	Beta rays
50–74–83	Betatron
32–43–64	Bibliography
25–47–58	Bifocal
14–32–47	Bilateral nystagmus
23–39–49	Binary digits
19–39–59	Binaural
13–21–27	Binding
35–52–56	Binocular
20–25–72	Bioacoustics
38–46–54	Biochemistry
13–22–75	Biography, Biographical
33–40–82	Biokinematics
33–35–77	Biological efficiency, relative (RBE)

F

15–43–62	Fixation (See "Fascination")
18–39–41	Fixation of eye
26–57–61	Flammability
17–19–51	Flash, light
13–60–62	Flatulence
34–38–62	Flexion
29–33–36	Flicker
30–32–48	Flicker fusion frequency
40–42–43	Flight, Flying
13–39–45	Flight characteristics
16–44–66	Flight clothing
42–47–64	Flight duration
21–24–25	Flight equipment
25–56–65	Flight, high-speed
50–55–78	Flight performance
48–57–58	Flight simulator
32–38–77	Flight surgeon
24–30–34	Flight test
66–74–86	Flight training
29–38–40	Flocculation
50–56–60	Flotation
22–29–55	Flow, constant; Flow rate
14–33–85	Flowers
27–56–58	Fluid volume
12–36–75	Fluids, cellular
13–49–60	Fluorescent lighting
48–62–65	Flutter
78–80–81	Flying, contact
40–42–43	Flying, Flight
12–21–82	Flying, instrument
11–49–77	Foam-in-place plastics
21–47–66	Food
17–26–57	Food handling techniques
19–46–60	Foot, Feet
29–64–67	Foot push button
14–23–63	Force
14–33–58	Forces, climatic
11–59–65	Forcing frequency
24–32–41	Foreign
17–40–42	Form

are applicable to more than one major subject, but only one code number is assigned to each detail subject. "Ejection seats," for example, could apply to articles classified under such major subject headings as Acceleration, Crash, and Seating, but always has the number 27–62–66. When that number is punched, all reference cards having information on ejection seats will fall out, no matter what the major subject of the article is.

The final step was the design of the punched card. Realizing that each person tends to remember articles or reports in different ways, and that this memory is not whole but partial, the group determined to design a system which would code an article as completely as practicable so that it could be retrieved no matter what information or how little of it a person recalled.

The punched card used by the Human Factors Group, shown in Fig. 1, is an 8 in. by 10½ in. McBee Company card with a double row of holes on all four edges. The major subjects are coded directly on the top rows. On the right side of the card, where the holes are numbered from 11–86, the detail subjects are coded. The outer row of the upper left hand side of the card is labeled "Month," "Decade," and "Year" for the date of the publication to be punched. The inner row of this section is reserved for coding the source or agency where the work was done. The lower half of the left side of the card is labelled from A–XYZ. On the outside row, the first and third letters of the first author's name are punched. On the inner row, the first and third letters of the second author's last name are coded. The bottom of the card has not yet been assigned, and thus allows for growth.

In the central field of the card is allotted space for all the information necessary to describe the reference and its physical location, for cross references to be listed, and for comments and an abstract. The size of the card makes it possible to carry more information, especially a longer and more detailed abstract, than the usual filing card.

In June, 1955, a report was written describing the use of the system. The Major Subject List and Detail Subject Index formed a part of the report.[2] At this time the system was put into operation.

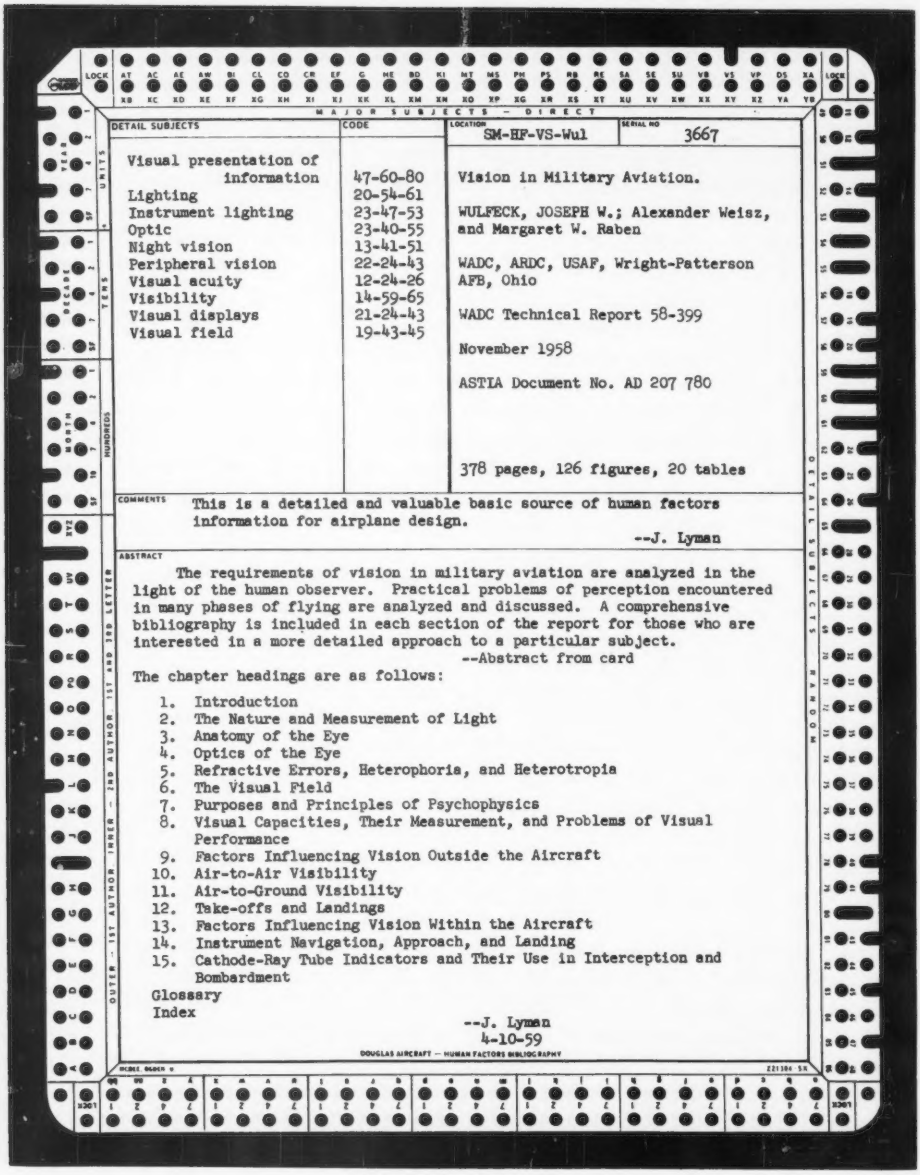
Further refinements were made as time permitted. Subject outlines were devised for most major categories. Each member of the group was asked to prepare an outline on the major subjects with which he was most familiar. Terms of the Detail Subject Index considered applicable to a particular major subject were grouped under that subject in a logical outline form. This subject outline serves as an aid to the abstractor, for he can find most of the terms he wishes to use in one or two pages, without having to leaf through the complete alphabetical listing of the Detail Subject Index. Table III shows two types of subject outlines.

Although the classification of an article is largely a matter of convenience for anticipated design use or accessibility for the human factors researcher, it was felt that a description showing what the major subject heading included would help to secure a reasonable uniformity of practice. The Human Factors Groups of the other Douglas Divisions were consulted in 1956 and through a joint effort, the reasonably definitive paragraphs were written. Examples are shown in Table IV. These descriptions are not mutually exclusive. They are not completely rigorous. They can be expanded or revised as need and experience dictate.

Last year an informal experiment was conducted within the group to determine the amount of agreement that could be obtained among the group members in choosing major subjects. Five members of the group — an engineer, an anthropologist, two physiologists, and a biochemist — each read the same ten articles in a copy of a technical physiological journal. They listed their choices of major subject (or subjects) for each article. The tabulation of the results showed that on first choices there was 100 percent agreement on one article, 80 percent agreement on five articles, 60 percent on three articles, and 40 percent on one article. When first and second choices were combined,

however, there was 100 percent agreement on all ten articles.

Establishment of the punched card system is a continuing process. A Source Code List is now being prepared. Six major subjects have been added since 1956, and new detail words and terms are placed in the glossary as the need arises.



DETAIL SUBJECTS

Visual presentation of information
Lighting
Instrument lighting
Optic
Night vision
Peripheral vision
Visual acuity
Visibility
Visual displays
Visual field

CODE

47-60-80
20-54-61
23-47-53
23-40-55
13-41-51
22-24-43
12-24-26
14-59-65
21-24-43
19-43-45

LOCATION: SM-HF-VS-Wul

SERIAL NO: 3667

Vision in Military Aviation.

WULFECK, JOSEPH W.; Alexander Weisz, and Margaret W. Raben

WADC, ARDC, USAF, Wright-Patterson AFB, Ohio

WADC Technical Report 58-399

November 1958

ASTIA Document No. AD 207 780

378 pages, 126 figures, 20 tables

COMMENTS

This is a detailed and valuable basic source of human factors information for airplane design.

--J. Lyman

ABSTRACT

The requirements of vision in military aviation are analyzed in the light of the human observer. Practical problems of perception encountered in many phases of flying are analyzed and discussed. A comprehensive bibliography is included in each section of the report for those who are interested in a more detailed approach to a particular subject.

--Abstract from card

The chapter headings are as follows:

1. Introduction
2. The Nature and Measurement of Light
3. Anatomy of the Eye
4. Optics of the Eye
5. Refractive Errors, Heterophoria, and Heterotropia
6. The Visual Field
7. Purposes and Principles of Psychophysics
8. Visual Capacities, Their Measurement, and Problems of Visual Performance
9. Factors Influencing Vision Outside the Aircraft
10. Air-to-Air Visibility
11. Air-to-Ground Visibility
12. Take-offs and Landings
13. Factors Influencing Vision Within the Aircraft
14. Instrument Navigation, Approach, and Landing
15. Cathode-Ray Tube Indicators and Their Use in Interception and Bombardment

Glossary
Index

--J. Lyman
4-10-59

DOUGLAS AIRCRAFT — HUMAN FACTORS BIBLIOGRAPHY

Fig. 1. Sample card.

TABLE III

Two Examples of Subject Outlines

A: Acceleration and Tumbling

Acceleration Producing Devices and Methods, Tests, and Experience

Surveys 12–19–41
General 27–43–44
Gravity 13–26–46
  Position of body 24–43–58
Vehicles, motor, etc. 31–39–48
  Military 15–21–26
  Aircraft 17–21–23
    Maneuvers 19–24–31
    Combat 11–60–65
    Dive bombing 29–32–51
    Training 11–31–55
    Climb 19–27–28
    Descent 15–22–30
    Zero-G, Weightlessness 46–53–55
    Landing and Braking 28–37–45
    Crashes 28–43–60
    Ditching 28–42–48
    Gusts and Buffeting 29–30–56
    Catapults 38–59–63
  Automobile, Truck, Bus 30–41–47
  Tanks, Track-laying devices 11–18–58
  Trains, Railroad 20–28–56
  Ships 19–21–62
  Submarines 21–39–44
  Space ships and Satellites 17–51–63
Escape devices 14–39–61
  Ejection seats 27–62–66
    Upward 29–50–61
    Downward 13–42–62
  Catapults 38–59–63
  Chutes and Slides 17–39–61
  Parachute 11–25–54
  Capsules 24–30–62
Testing Devices, Tests 50–52–57
  Training devices 41–51–61
  Flight simulator 48–57–58
  Centrifuge 41–50–56
  Spin table 33–45–53
  Sled 21–33–38
  Rocket 14–37–42

Acceleration Producing Devices and Methods, Tests, and Experience (cont.)

Testing Devices, Tests (cont.)
  Tilt table 21–27–46
  Dummies 29–30–50
  Shake tables 36–44–49
  Elevators 32–46–66
  Impact devices, Drop tests 24–31–52
  Barany chair 36–40–54
  Swings 42–48–53
Crashes 28–43–60
  Crash landings 14–40–62
Acrobatics and Sports 13–22–41
Accidents 52–62–64
Impacts 24–31–52
  Falls, Drop tests, Blows
Blast 44–53–58
Objects struck causing deceleration
  Pads 14–36–42
  Cushions 32–42–52
  Canopies 34–36–48
  Structure 27–48–54
  Shock mounting 12–43–66
  Ground or floors 36–43–65
  Water 37–48–63

Acceleration Conditions, Physical Parameters

Acceleration, Deceleration, G 11–32–49
  Surveys 12–19–41
  General 27–43–44
  Direction (of force) 24–30–40
    Positive 31–32–47
    Negative 11–25–58
    Lateral 21–24–40
    Transverse 14–15–47
      Positive 31–32–47
      Negative 11–25–58
    Zero-G, Weightlessness 46–53–55
    Harmonic motion 27–48–49
    Forces 14–23–63

TABLE III (cont.)

Acceleration Conditions (cont.)	
Tumbling and spinning	35–45–66
Surveys	12–19–41
General	27–43–44
Radial acceleration	22–26–35
Spin	33–45–53
Forces	14–23–63
Parameters	15–16–42
Duration	12–20–56
Rate of onset	37–49–59
Amplitude	28–38–49
Crash	28–43–60
Impact	24–31–52
Speed, rpm variation	12–35–60
Frequency	32–33–57
Forces	14–23–63
Velocity	29–35–45
Acceleration, G	11–32–49
Harmonic motion	27–48–49
Complex	31–47–49
Positions of body	24–43–58
Surveys	12–19–41
Standing, Vertical	22–28–43
Seated	21–36–63
Forward facing	19–28–59
Aft facing	31–38–41
Prone and Supine	59–60–66
Litters, Stretchers	11–45–52
Berths	41–47–66
"Sleeperettes"	41–50–59
Spin centers	34–39–41
Center of gravity	20–22–43
Heart	34–49–53
Head	17–25–57
Appendages	20–41–47
Acceleration Effects	17–37–63
General	27–43–44
Behavior	16–17–40
Surveys	12–19–41
Mammals	23–26–45
Rats, Rodents, Mice	28–41–44
Physical effects on body	
Blood pressure	12–36–41
Fractures	31–36–45
Injury	25–32–62
Pressure on body	47–52–57
Permeability	20–36–51

Acceleration Effects (cont.)	
Physiological effects	26–49–66
General	27–43–44
After effects	27–48–66
Recovery	43–54–63
Motion sickness	22–50–59
Functions	18–22–32
Respiration	11–38–44
Anatomy (See below)	
Anatomy	28–29–42
Nervous system	40–53–54
Autonomic nervous system	32–39–50
Central nervous system	34–39–41
Brain	37–59–62
Consciousness	21–25–30
Sleep	12–47–51
Cerebral hemorrhage	41–60–61
Blackout	14–32–51
Fainting	32–48–52
Pain	12–14–55
Convulsions	27–35–59
Circulatory system	25–46–66
Heart	34–49–53
Pulse rate	25–34–62
Blood pressure	12–36–41
Membrane	21–44–61
Permeability	20–36–51
Endocrine system	35–40–51
Adrenalin	24–34–65
Sense organs	38–44–49
Eye, Optic	23–40–55
Retina	16–53–65
Conjunctiva	15–62–66
Perception	12–13–59
Acuity	22–52–60
Blindness	28–39–49
Blackout	14–32–51
Redout	28–39–49
Petechiae	21–27–31
Nose	30–44–49
Ear	17–46–56
Hearing	24–26–56
Kinesthetic senses	21–39–65
Labyrinth	34–36–65
Vestibula	20–37–52
Digestive system	24–38–66
Stomach	23–24–46
Nausea	21–46–61

TABLE III (cont.)

Acceleration Effects (cont.)

Digestive system (cont.)
- Kidney 19–43–59
- Liver 33–42–45
- Intestine 21–26–35

Muscular system 11–17–53
- Appendages 21–41–47
  - Force 14–23–63
  - Strength 30–49–54
- Abdominal 30–39–40
  - Pressure 47–52–57

Skeletal system
- Spinal column 39–49–51
  - Backache 36–40–41
- Bones 17–21–64
  - Fractures 31–36–45
- Head 17–25–57

Respiratory structure 11–38–44
- Lungs, Pulmonary 19–42–44
- Head 17–25–57
- Cells 23–40–52
  - Permeability 20–36–51
- Appendages 21–41–47
- Facial contours 20–33–65

Modifying factors
- Body or functional states 34–41–55
  - Exercise 20–50–63
  - Resistance 12–21–29
  - Tolerance 12–32–62
  - Fatigue 26–27–53
  - Age 24–29–38
  - Heart disease 34–49–53
  - Fitness 13–21–52
  - Somatatypes 15–28–45
  - Dimensions 26–50–57
  - Pregnancy 27–37–58
  - Anoxia 14–24–35
- Chemical or physical agents
  - Drugs 29–56–66
    - Stimulants 13–14–27
    - Depressants 38–41–46
  - Other medication 16–23–66

Psychological effects 25–42–65
- General 27–43–44
- After effects 27–48–66
- Recovery 43–54–63

Acceleration Effects (cont.)

Psychological effects (cont.)
- Motion sickness 22–50–59
- Functions 18–22–32
  - Respiration 11–38–44
- Amusement 40–55–59
- Comfort 11–35–52
- Discomfort 35–41–49
- Riding quality 20–47–60
- Annoyance 13–16–30
- Anxiety 28–56–62
- Vertigo 21–42–53
- Nausea 21–46–61
- Giddiness 29–42–64
- Orientation 24–33–38
- Illusions 22–47–66
- Flicker fusion frequency 30–32–48
- Perceptual, Perception 12–13–59
- Pressure 47–52–57
- Pain 12–14–55
- Errors, pilot 18–30–63
- Reaction time 20–55–58
- Behavior 16–17–40
- Motor skills 13–54–58
  - Coodination tests 43–48–54

Measurements, Tests, Measuring Devices 19–54–61
- Electrocardiogram 25–29–50
- Electroencephalogram 11–32–47
- Coordination tests 43–48–54
- Freeze, Quick-freeze 37–41–50

Protective Devices and Measures 24–37–48

General 27–43–44

Anti-G 13–21–25
- Clothing 34–49–52

Harness 15–22–52
- Belts, lap, seat 13–40–42
- Inertia lock 31–46–64

Arm rest and supports 45–51–62

Somatatype 15–28–45

Exercise 20–50–63

Strength 30–49–54

Shock mounting 12–43–66

TABLE III (cont.)

Protective Devices and Measures (cont.)

Pads 14–36–42
Cushions 32–42–52
Damping 28–39–41
Position 24–43–58
Adaptation 25–37–44
Resistance 12–21–29
Drugs 29–56–66
Motion sickness preventives 11–59–62
Training, Conditioning 11–31–55
Seats 21–36–63
  Aft facing 31–38–41
  Forward facing 16–28–59

Protective Devices and Measures (cont.)

Mechanisms 16–25–34
Gust alleviation 16–49–60

Special Descriptive Charts and Techniques

Charts 14–53–64
Photographs 28–48–64
Instruments 23–33–55
  Accelerometers 23–33–55

B: Vibration

A. Sources of vibration 14–23–43
  Airplane 17–21–23
  Automobile 30–41–47
  Bus 30–41–47
  Engine 12–23–58
    Jet 32–37–45
    Reciprocating 12–20–28
    Rocket 14–37–42
  General 27–43–44
  Ground 36–43–65
  Propeller 51–57–66
    Turboprop 11–12–13
  Ship 19–21–62
  Theory 20–23–28
B. Instrumentation 23–33–55
  General 27–43–44
  Instruments 23–33–55
  Measuring techniques 19–54–61
  Theory 20–23–28
C. Physics of vibration 15–31–38
  Attenuation 46–47–58
  Complex variable 17–34–62
  Coupled 20–31–58
  Damping 28–39–41
  Displacement 29–37–40
  Forcing frequency 11–59–65
  Impedance 12–48–60
  Longitudinal 48–49–51
  Mass 20–25–41

C. Physics of vibration (cont.)
  Natural frequency 53–57–64
  Phase angle 40–56–66
  Shock mounts 12–43–66
  Spring rate 16–42–44
  Transverse 14–15–47
  Velocity 29–35–45
  Vertical 22–28–43
D. Vibration effects 15–31–45
  Arms 20–41–47
  Balance 33–40–42
  Digestive system 24–38–66
  Duration 12–20–56
    Amplitude 28–38–49
    Displacement 29–37–40
    Frequency 32–33–57
    Rate of change 37–49–59
  Fingers 13–53–59
  Foot, Feet 19–46–60
  Head 17–25–57
  Legs 20–41–47
  Mental reactions 26–29–48
  Muscular system 20–25–59
  Vascular system 14–54–58
  Vision 22–65–66
E. Criteria 24–47–58
  Annoyance 13–16–30
  Comfort 11–35–52
  Safety 43–52–63

TABLE III (cont.)

Vibration Glossary

Abdominal	30–39–40	Cells	23–40–52
Acceleration	11–32–49	Center of gravity	20–22–43
Accommodation	18–21–65	Cerebral disfunction	36–48–55
Adaptation	25–37–44	Charts	14–53–64
Aerodynamic	31–39–45	Chronic	37–50–53
After effects	27–48–66	Circulatory system	25–46–66
Age	24–29–38	Classifications	19–30–31
Air	11–15–44	Clinical reflexes	38–56–60
Aircraft	17–21–23	Coding	38–41–48
Air sickness	22–50–59	Comfort	11–35–52
Amplifiers	19–58–59	Complex	31–47–49
Amplitude	28–38–49	Configuration	13–27–42
Analysis	20–35–49	Coordination tests	43–48–54
Anatomy	28–29–42	Coupled	20–31–58
Annoyance	13–16–30	Crashes	28–43–60
Anxiety	28–56–62	Criteria	24–47–58
Aorta	33–42–46	Critical	51–58–63
Appendages	20–41–47	Cushions	32–42–52
Application	14–51–53		
Arm rest	45–51–62	Damping	28–39–41
Arms (See Appendages)	20–41–47	Dental pain	16–28–36
Artery, Arterial	14–50–51	Design	18–19–47
Attenuation	46–47–58	Deviation, standard	47–54–66
Automobile	30–41–47	Digestive system	24–38–66
Autonomic, Autonomic nervous system	32–39–50	Direction	24–30–40
		Disadvantages	19–55–58
Backache	36–40–41	Discomfort	35–41–49
Bacteria	25–51–64	Disfunction, cerebral	36–48–55
Balance	33–40–42	Disorders	13–26–47
Bandwidth	20–47–57	Displays	23–31–41
Beats	24–49–53	Distortion	11–25–56
Behavior	16–17–40	Duct	16–25–64
Berths	41–47–66	Duration	12–20–56
Blast	44–53–58	Dynamics	13–54–59
Blood	11–31–65		
Blood pressure	12–36–41	Ear	17–46–56
Body	17–27–64	Effect	17–37–63
Body build	15–28–45	Effects, physiological	26–49–66
Body temperature	20–33–36	Effects, psychological	25–42–65
Bones	17–21–64	Efficiency	30–40–64
Brain	37–59–62	Ejection seats	27–62–66
Brain concussion, damage	12–25–57	Electrocardiograms	25–29–59
Brief, Brevity	22–23–55	Electroencephalograms	11–32–47
Buffet	12–26–35	Electronic	36–47–48
Buffeting and gusts	29–30–56	Energy	15–36–39
		Engines	12–23–58
CAA requirements	13–32–42	Errors, pilot, human	18–30–63
Cabin	39–63–64	Evaluation	34–45–64
Causes	32–37–44	Excessive	24–34–56
Cavity, peritoneal	27–47–50	..... etc.	

TABLE IV

Descriptions of Major Subject Headings

Acceleration and Tumbling

Studies of the physical, physiological, and psychological effects of acceleration on man and animals. Magnitudes, durations, direction and rate of application of acceleration. Systematic formulation of degrees of human and animal tolerance.

Acoustics (Physical)

Noise sources, instrumentation for noise measurement, interior and exterior noise levels, reduction techniques, properties of insulation materials, acoustical installations

Air Evacuation and Transportation

Design of airborne hospitals for military and civilian needs, including background information and operational data. Zones of operation, casualty statistics, specialized requirements of hospital aircraft. Loading, space requirements, personnel, comfort, emergency landings, power requirements.

Arrangement of Workspace

The design of duty stations for efficient use by personnel in aircraft, combat information centers, ground control centers, control towers, etc., as determined by consideration of man's visual, aural, anthropometric and dynamic properties and mental capabilities.

Bibliographies

Bibliographies, sources of published reference material, and institutions through which human factors material can be obtained. Information on various library systems and techniques of sorting and classifying information. Bibliographies on all the major fields are filed in this section.

Clothing and Protective Equipment

Items attached to man as personal equipment, such as ear protection, crash protection, bail-out protection, oxygen masks. In general, these will be cross-referenced in relation to other subjects. Philosophy of integrated equipment.

Controls

Operability of controls and knobs as a function of their design, mode of operation and relationships to displays. Transfer function of man as a control element. See also Psychology, Arrangement of Workspaces, Aural Presentation of Information, Visual Presentation of Information, and Hearing.

Crash Studies and Safety

Accident statistics for various transportation modes, evaluative criteria useful in accident analysis, design lessons from accident studies, philosophy of design for safety, safety publications.

Environmental Factors

The physical, chemical and biological environment of man as a passenger, air or ground crew man, with special emphasis on external environment and climatology. Will correlate with other fields.

Escape

The problem of escape from aircraft. Physiological limitations to escape at various speeds and altitudes. Includes emergency ground evacuation and ditching of transport aircraft. (See also Clothing and Protective Equipment and Acceleration and Tumbling.)

General Considerations

Role of human factors concepts in aircraft design. Philosophy of human factors approach to design. Wider significances of major subjects in aircraft, industry, and society. Information not readily assignable to major subjects (i.e., temporary catch-all). Airplane models. Articles on human factors, passenger comfort, etc., with little factual information, and books, articles, and symposia covering a number of major subjects. (These will also be classed chapter by chapter under the individual subjects.) Organization of a human factors team.

Hearing

Audiometry, psycho-acoustics, psychological effects of sound, physiological effects of sound, protective devices (see also Clothing and Protective Equipment), criteria of annoyance, speech interference, deafness inducing sounds, speech and information.

Human Body Dimensions (Anthropometry)

Measurement of static body dimensions, including centers of gravity, density, volumes, areas, etc. Cross reference with Arrangement of Workspace and Kinesiology (Dynamic Anthropometry) as regards dynamic aspects such as moments of inertia.

Instrumentation

Includes instrumentation such as pickups, amplifiers, computers, recorders, and data reduction equipments used in human factors experimentation. Specific modes of data presentation to human operators (i.e. displays) should be classified in one of the "Presentation of Information" sections (VP or XA).

Kinesiology (Dynamic Anthropometry)

Man in motion. Reaches, pulls, forces that can be exerted by man. Speed of motion, accuracy of motion. (See also Psychology for reaction times.) Control of body. Measurement of motion and degree of freedom.

Mathematical Techniques

Mathematical procedures most useful to various aspects of human factors work. Short cuts, nomographs, special techniques.

Motion Sickness

Effects of motions which may characteristically produce motion sickness, as a special case of response to reciprocating motion. Psychological and physiological causes of motion sickness. (See also Vibration and Vestibular Phenomena.)

Physiology

General physiology, anatomy, normal and abnormal physiological states, tests and instrumentation. (See also Respiration, Environmental Factors, Radiation Biology, Decompression Sickness.) Health statistics, morbidity and mortality.

Psychology

General and experimental psychology, psychological items not covered elsewhere, synthesis of work in other sections, psychological techniques (see also Mathematical Techniques), and analysis of crew efficiency, work decrement, response of the human system, behavioral patterns.

Radiation Biology

The effects of nuclear and cosmic radiation on humans and other organisms. Protection, tolerance dosage, genetic effects, and functional disturbances including psychological effects. Nuclear aircraft design problems and reactor problems are included where these have a bearing on safety.

Respiration

Physiology of all aspects of breathing, including the effects of oxygen, carbon dioxide and pressure; also includes the effects of decompression on the breathing structures and cardiovascular system.

Sanitation

Government regulations, military requirements, physiology of eliminative process, handling of in-flight wastes, control of disease vectors, odors, aesthetic considerations.

Seats and Berths

Dimensional and functional requirements of seated passenger and crew members, including cushion requirements. Design criteria and procedures. Problems of berths for vibration isolation.

Survival

What to do after safe touchdown on land or sea. Human factors requirements for equipment needed for land and sea survival.

Toxicity

Includes the physiological and psychological effects of chronic and acute exposures to toxic, anesthetic, and irritant gases, vapors, fumes, mists, dusts, liquids, and solids. Toxic thermal breakdown products of aircraft components are included.

Vibration, Gusts and Buffeting

Dynamic physical impacts to humans, and responses thereto. Primarily repetitive impacts, with the exception of motion sickness. Criteria for judging body responses. Design methods for eliminating impacts. Frequencies, amplitudes, and durations. Effects on various parts of human systems.

Vision

Physiology and optics, physical factors affecting visibility, fundamental visual studies, illusions, surveys, perception.

Visual Presentation of Information

The design of displays for the visual presentation of information to human operators.

Decompression Sickness

The special problems of physiology and physics related to decompressions in airplanes, caissons, and submarines. Design considerations which will prevent or alleviate decompression experiences, specifically applies to decompression sickness, including bends, chokes, neurologic symptoms, creeps, flatulence, aerosinusitis, aerodontitis, and other symptoms caused by the expansion or creation of gas in the body due to non-explosive decrease of pressure on the body.

Auditory Presentation of Information

The design of displays for the aural presentation of information to the human operator.

Simulators and Training Aids

Descriptions, uses, limitations, and evaluation of simulators and training aids.

OPERATION OF THE SYSTEM

As articles are received in the group, they are assigned a serial number for the purposes of logging-in and charging-out. (This also gives a rough count of the number of references in the files.) Each article is assigned to the technical person in the group who has the most interest and capability in the subject to be read and abstracted. On a worksheet of bond paper, which is a replica of the card itself, besides writing an abstract or using the author's abstract, the abstractor also indicates the major subject under which the reference and card should be filed. Other major subjects are punched if the article logically falls into more than one major field. The abstractor also lists the detail subjects to be coded. In his choice of detail subjects he indicates the main phases of information contained in the article, and those of especial interest to design problems. Up to fifteen cross references can be listed without having an undue number of unwanted cards fall out during the sorting operation.

Under "Comments" the abstractor may make brief notes as to the value of the report in general, or note any especially useful information for human factors and design problems. The number of references, charts, tables, and pages of a reference are also noted on the card.

It has been estimated that it takes from five to fifteen minutes longer to finish an article when an abstract is written, but the opinion has been expressed that having to abstract tends to make one read more carefully and remember longer.

After being typed and punched, the cards are filed. Although it is not necessary to file the punched cards alphabetically or in any special sequence, the cards in the Human Factors Group

are filed by major subject. This reduces the number of cards which must be handled during a sorting operation, since needed information usually falls under one, two, or three major headings. For example, when looking for information on oxygen masks, only the cards filed under "Clothing and Protective Equipment" would usually need to be searched in order to get most of the references on this subject.

The references themselves, if they are to be kept in the group, are also filed under major subject headings, and in addition, are arranged alphabetically by author. The "Location" box on the card indicates where the physical article is filed. An article on acceleration by Smith which is the property of the Human Factors Group would show this code in the Location box: SM-HF-AT-Smi. This stands for: Santa Monica (Division), Human Factors (Group), Acceleration (major subject under which card and reference are filed), Smith (first author). Indicating the physical location of an article on the card has proven especially valuable for articles which have been difficult to find and which could not be reproduced or kept in the group.

Approximately 4000 entries have been processed into the system. An estimated backlog of 2000 articles is on hand.

MERITS OF THE SYSTEM

The marginal punched card system provides the searcher with a variety of means for locating material. A searcher need only to indicate to the librarian one or more key words, or authors, or approximate dates, for example, in order to institute a profitable search.

The punched card system is not designed to locate one particular piece of information or a single reference with one punch, however. A small group of cards referencing articles on a certain subject or by a particular author will be separated from the main pack during a sorting operation. These can then be quickly hand-sorted for a single reference, or all cards on a certain subject can be reviewed by the person seeking information and he can then ask for those references that seem best for his particular problem.

Other advantages of the punched cards system are these:

1. A single card carries a complete cross index, which eliminates multiple cross-subject files, and provides a convenient mechanical means of searching for a combination of factors.
2. Because the operation of sorting is relatively simple, personnel in charge of operating the system need little special training.
3. A minimum of equipment is needed, and the cost is reasonable.
4. The fact that cards do not have to be filed or maintained in alphabetical order saves time and tempers.
5. If the time comes when there are so many cards that needle sorting becomes laborious and inexpedient, it will not be a hard task to convert to a high speed automatic sorting system.
6. The system as set up in the Human Factors Group allows for growth. At the present time only thirty-two of the fifty-two holes available to code major subjects are being used. Since the detail subjects are not directly coded, the only limit is when all the combinations of numbers from 11–86 in three pairs are used up. As was noted earlier, the two rows on the bottom of the card have not yet been assigned.

There are other nonmechanical merits of this system. For one thing, the consistent use of the detail subject terms has helped to standardize the language and thinking of the group, and enable the psychologist to talk to the physiologist in common terms.

The punched cards are helpful for writing reports. Several years ago a survey was made of the literature on radiation biology. Over 700 references were read and abstracted, and the information recorded on the punched cards. The investigator was able to retrieve the information when writing his reports by having the cards sorted and resorted as each topic to be covered was approached. The cards could be needled to sort out all those bearing reference to alpha particles, for example, and then resorted for

beta particles. Similarly, all cards bearing reference to irradiation of the skin could be found, and then this group sorted for various subtopics of interest — erythema, burns, histological changes, etc. The investigator found that to a great extent he was able to use the abstracts on the cards without having to go back to each original article.

The outcome of this literature search and review was Levedahl's recent article "A Survey of Radiobiology for Engineers."[3]

When articles are processed as they are read, each person's reading benefits the others in the group. One human factors specialist can scan the cards, for instance, and keep informed of new information or developments which might be of most direct interest to another human factors worker.

If a person, as he works on his various problems, leaves a trail of abstracts of the literature he has searched, it is much easier for a new person to pickup, follow, or continue the work in the event that the original investigator turns to new problems or leaves the company.

The marginal punched card system in reality constitutes a collection of annotated and evaluated bibliographies. The system has especial value because the abstracting is done by the technical people working in the human factors field, and because personal comments as to the value of an article to design problems can be made and recorded. These merits, however, limit the freedom of circulation since the comments may sometimes be caustic, but the utility, flexibility, and ease of expansion are significant advantages over the preceding chaos.

REFERENCES

1. Society of Aircraft Materials and Process Engineers, SAMPE Punched Card Indexing System. May 19, 1953.

2. Human Factors Group, "A Marginal Punched Card System for Human Factors Data." Douglas Aircraft Company, Inc., Santa Monica, California, Report No. SM–18881. Revised August 14, 1957.

3. LEVEDAHL, BLAINE H., A survey of radiobiology for engineers. *Human Factors,* 1(3), 1, 1959.

The Tufts Index to Human Engineering Literature

DONALD B. DEVOE, Operational Applications Laboratory, U.S.A.F. Cambridge Research Center, Bedford, Massachusetts, and **EZRA V. SAUL,** Institute for Applied Experimental Psychology, Tufts University, Medford, Massachusetts.

The problems encountered in the development of a control system for the human engineering literature are briefly reviewed. The heterogeneity of the system and its flexibility is demonstrated in a topical outline and in selected examples of search terms.

For five years, Tufts University[1] has been assembling and indexing the technical literature relevant to "human engineering" (defining the area broadly enough to be synonymous with "human factors" for the purposes of this article). The methods adopted for organizing the literature of human engineering were developed after considerable study of current literature in the field of documentation, visits to some dozen major bibliographical enterprises, and consultation with several outstanding documentation specialists.[1] Since the Tufts project was designed to meet the needs of a wide variety of potential clients, it is felt that a description of the principal features of its indexing system may be of use to many human factors groups.

Human engineering literature is characterized by its heterogeneity, its rapid growth, and the fact that a good part of its value lies in its applicability to problems. The heterogeneity of human engineering literature — its origin in a wide variety of scientific and engineering fields (including engineering, psychology, medicine, anthropometry, and numerous others) — imposes an integrating and translating function on any effective indexing system. The rapid, almost explosive, growth of the literature demands flexibility in the index. The applied nature of the human factors field requires that an index to its literature be problem-oriented. These criteria apply generally to any index of human engineering literature. The specific needs and facilities of a particular user will impose additional criteria for his own indexing system.

The Tufts indexing system centers about a *topical outline* (reproduced in its current form at the end of this article). The outline has some 15 major headings, with numerous subheadings and sub-subheadings to fill out the major areas. These headings are primarily applied or problem-oriented in nature, although provision is made to break down more basic literature in considerable detail. The outline may be considered a logically related set of descriptors that provides structure to the field of human engineering and permits a systematic search of the literature to a relatively detailed level. Through contiguous and cross-referenced headings, the searcher gains some knowledge of unfamiliar areas even as he conducts his search. So the topical outline meets the criterion for integration.

The topical outline was the result, too, of additional considerations. Whereas breadth and detail in the set of descriptors facilitate retrieval, too many terms, particularly in unstructured array, seriously hamper the speed and consistency of the coders who must relate the relevant terms to each document that is encoded. Knowledge of the gross structure of the outline permits rapid and accurate coding of documents even while the coder is learning the finer details of

[1] This work was performed at the Institute for Applied Experimental Psychology at Tufts University under support from the U.S.N. Training Devices Center, Port Washington, Long Island, New York, the Office of Naval Research, Washington, D.C., and the U.S.A.F. Office of Scientific Research, Washington, D.C. The opinions expressed are those of the authors and not necessarily those of the sponsoring agencies.

the outline. Furthermore, financial limitations dictated a manual retrieval system; so the topical outline has been used to provide category headings for a subject matter card file. After each document has been coded to all relevant headings, a card citing the document is placed in the file behind every heading used. Ready-made bibliographies may be retrieved by simply going to the desired headings and removing the cards filed there.

Ordinarily flexibility is somewhat reduced when an indexing system is built around a topical index. However, the Tufts index (in its working form) is not tied to a dedicated numerical system, and headings may be inserted, deleted, or shifted at will, provided only that the topical outline is modified to show these changes. The periodic publication of the current outline has given adequate flexibility to the system to date. The terms may be numbered for conversion to machine retrieval methods; however, it is recommended that the numbers be assigned without sequential restrictions, so that shifts and interpolations can be made without the need for renumbering and recoding. At Tufts, a random numbering was used for the initial terms, and as new terms are added, they are simply given the lowest unused number.

At Tufts, documents are identified and filed by a single accession number. Retrieval and filing can be easily accomplished by unskilled clerks, and the numbering permits easy conversion to machine retrieval systems. Browsing through the documents is not too rewarding with accession-number shelving, but the preparation of author and source card files in addition to the subject matter file based on the topical outline, permits highly productive browsing through the cards — a procedure that also has the advantage of keeping searchers separated from the document shelves, thus reducing the problems of misplaced and lost documents.

The topical outline alone does not provide the translation function set as a desirable criterion for an index of human engineering literature. And, although its headings are related to problem areas, they leave much to be desired still in tracking down literature relevant to a specific problem. Tufts has attempted to solve these problems with an *alphabetical index* of search terms (a sample of which follows the Topical Outline at the end of this article). The idea of the alphabetical index is to incorporate every term that the experienced coders have found or feel might be useful in describing problems to which the data of the document being coded might be applied. Although the correlation of each of these terms to every relevant document has been beyond the scope of manpower and finances at Tufts, each term has been related to the relevant portion of the topical outline. The alphabetical index provides translation by including the terms characteristically used in the jargons of the various fields that overlap in human factors and relating all these terms to the relevant terms in the topical outline. Terms descriptive of typical problems are included, so that often a searcher can start by looking up words descriptive of his problem in the alphabetical index, which in turn leads him to the appropriate (even though unfamiliar) term in the topical outline, and thence to the relevant documents. The alphabetical arrangement permits very rapid retrieval.

In summation, this article has described the Tufts indexing and retrieval system for the human engineering literature. This system has been designed to meet such problems as: heterogeneity of subject matter content, heterogeneity of user population, growth and development in the subject matter fields, and efficiency in user location and retrieval. The reader interested in examining concrete products deriving from the Tufts system is directed to the recent publications[2,3] of the Human Engineering Information and Analysis Service Project at Tufts University.

REFERENCES

1. DEVOE, D. B., SALOMON, A., and SAUL, E. V., A proposed system of bibliographic services in human engineering. 15 pp. and appendices. Contract Nonr 494(09). Tufts University Report submitted to Special Devices Center, Office of Naval Research, May 1955.

2. Office of Naval Research, Report ACR–24. "Human Engineering Bibliography (1955–1956)," 306 pp., by the Project Staff, Human Engineering Information and Analysis Service, Institute for Applied Experimental Psychology, Tufts University, Oct. 1957. (Armed Services Technical Information Agency AD149950, Office of Technical Services, Department of Commerce PB131507.)

3. Office of Naval Research Report ACR–32. "Human Engineering Bibliography (1956–1957)," 360 pp., by the Project Staff, Human Engineering Information and Analysis Service, Institute for Applied Experimental Psychology, Tufts University, Oct. 1958. (Armed Services Technical Information Agency AD205931, Office of Technical Services, Department of Commerce PB131507S.)

APPENDIX I

Topical Outline of the Literature in Human Engineering *

1.0.0 Human Engineering: methods, facilities, equipment and general references

- 1.1.0 Bibliographies and general references
- 1.2.0 Methods and design procedures
  - 1.2.1 Statistical methods
  - 1.2.2 Methods of task description
  - 1.2.3 Psychophysical methods
  - 1.2.4 Physiological methods
  - 1.2.5 Special techniques
- 1.3.0 General equipment and apparatus
- 1.4.0 Facilities in human engineering
- 1.5.0 Safety and accidents
  - 1.5.1. Motor vehicle safety
  - 1.5.2 Air safety

2.0.0 Systems of men and machines

- 2.1.0 Bibliographies and general references
- 2.2.0 Subsystems and total systems
  - 2.2.1 Productivity
  - 2.2.2 Work organization and layout
  - 2.2.3 Patterns of communication
  - 2.2.4 Control and monitoring functions
  - 2.2.5 Assignment of functions to men or machines
- 2.3.0 Evaluation of specific systems
  - 2.3.1 Multi-manned aircraft
  - 2.3.2 Aircraft traffic control
  - 2.3.3 Combat information and control centers
  - 2.3.4 Maintenance scheduling and trouble-shooting

3.0.0. Visual inputs and processes

- 3.1.0 Bibliographies and general references
- 3.2.0 Natural ambient lighting
  - 3.2.1 Daytime light
  - 3.2.2 Twilight and night
  - 3.2.3 Special conditions affecting visibility
  - 3.2.4 Glare
- 3.3.0 Artificial ambient lighting
  - 3.3.1 Considerations of illumination
  - 3.3.2 Lighting systems, outdoor
  - 3.3.3 Lighting systems, indoor
  - 3.3.4 Illumination, unusual characteristics
- 3.4.0 Lighting of instruments
  - 3.4.1 Direct lighting and floodlighting
  - 3.4.2 Indirect lighting — edge, ring, rear
  - 3.4.3 Color and intensity of illumination
  - 3.4.4 Comparisons of methods and types
- 3.5.0 Radarscopes and other cathode-ray tube displays
  - 3.5.1 Signal detectability
  - 3.5.2 Range and bearing scales and aids
  - 3.5.3 Size, shape, lighting, etc., of screen
- 3.6.0 Television and motion picture displays
- 3.7.0 Pictorial and symbolic displays
  - 3.7.1 Outside-in and inside-out displays
  - 3.7.2 Combining pictorial and symbolic display elements
  - 3.7.3 Comparisons among types of displays
- 3.8.0 Indicators and scales
  - 3.8.1 Counters
  - 3.8.2 Pointers
  - 3.8.3 Scales: shape, size, and direction of increase
  - 3.8.4 Scales: divisions and markings

* The utilization of sequential code numbers in this form of the Topical Outline is restricted to certain published forms and is intended to facilitate utilization of the outline by non-Tufts personnel. The Tufts master file uses the unstructured numbering system.

- 3.8.5 Design of scales for qualitative readings
- 3.8.6 Standardization and comparison of types
- 3.9.0 Legibility of letters, numerals, and other symbolic forms
  - 3.9.1 Design of characters
  - 3.9.2 Color and contrast between symbol and background
  - 3.9.3 Viewing conditions
- 3.10.0 Printed materials
  - 3.10.1 Graphs and tables
  - 3.10.2 Maps and charts
  - 3.10.3 Decals, instruction cards, check lists, etc.
  - 3.10.4 Comparisons of types of printed materials
- 3.11.0 Camouflage or concealment
- 3.12.0 Visual coding
  - 3.12.1 Object characteristics
  - 3.12.2 Light coding
- 3.13.0 Optical aids
  - 3.13.1 Sights, reticles, binoculars, periscopes
  - 3.13.2 Filters, special glasses, goggles, visors
- 3.14.0 Other factors affecting visual performance
- 3.15.0 Basic visual data related to design and use of equipment
  - 3.15.1 Deviations and anomalies
  - 3.15.2 Threshold visibility
  - 3.15.3 Adaptation, pre-adaptation, and pre-exposure
  - 3.15.4 Perception of color
  - 3.15.5 Brightness discrimination
  - 3.15.6 Acuity
  - 3.15.7 Special effects of fixation or exposure time
  - 3.15.8 Eye movements
  - 3.15.9 Perception of depth, distance, and size
  - 3.15.10 Perception of form, contour, and pattern
  - 3.15.11 Perception of number, angle, and direction
  - 3.15.12 Perception of movement
- 3.16.0 Equipment and methods for basic and applied problems
  - 3.16.1 Tests of color vision
  - 3.16.2 Other tests of visual performance
  - 3.16.3 Equipment and methods for basic research
  - 3.16.4 Simulators for specific applied problems

4.0.0 Audition: includes speech production and intelligibility

- 4.1.0 Bibliographies and general references
- 4.2.0 Ambient noise
  - 4.2.1 Measurement of noise level and composition
  - 4.2.2 Noise reduction and control
  - 4.2.3 General industrial and equipment noise
  - 4.2.4 Aircraft noise
  - 4.2.5 Submarine and ship noise
  - 4.2.6 Effects of ambient noise and blast on performance
  - 4.2.7 Noise-induced hearing loss
- 4.3.0 Effects of auditory equipment components
  - 4.3.1 Input devices
  - 4.3.2. Transmission devices
  - 4.3.3 Output devices
- 4.4.0 Evaluations of specific speech communication systems
  - 4.4.1 Telephone and intercom systems
  - 4.4.2 Radio systems
- 4.5.0 Evaluations of specific nonverbal display systems
  - 4.5.1 Intermittent warning and signaling devices
  - 4.5.2 Telegraphic systems
  - 4.5.3 Sonar and other underwater sound systems
  - 4.5.4 Flybar
- 4.6.0 Characteristics of auditory signals relative to coding
- 4.7.0 Special auditory skills
- 4.8.0 Basic data in the production and perception of speech

4.8.1 Basic characteristics of speech
4.8.2 Speech audiometry and articulation testing
4.8.3 Speech masking and the signal-to-noise ratio
4.8.4 Speech distortion
4.8.5 Individual differences and anomalies
For Span of attention — see 13.2.5
4.8.6 Language design
For Training in voice communication — see 14.1.0
4.8.7 Synthetic speech
4.9.0 Basic data in audition
4.9.1 Basic attributes: pitch
4.9.2 Basic attributes: loudness
4.9.3 Basic attributes: timbre, duration, etc.
4.9.4 Thresholds and related phenomena
4.9.5 Aftereffects of stimulation
4.9.6 Stimulus mixture
4.9.7 Sound localization
4.9.8 Auditory patterns and meaning
4.9.9 Psychological scaling
4.9.10 Auditory performance, individual differences and anomalies
For Nonverbal auditory training — see 14.1.0
4.9.11 Physiological mechanisms
4.9.12 Equipment and methods used in research in audition

5.0.0 Other sensory inputs and processes

5.1.0. Touch and vibration
5.1.1 Basic processes and data
5.1.2 Texture
5.1.3 Tactile coding
5.1.4 Tactile and vibratory stimuli as signals and displays
5.1.5 Equipment and methods in H.E. research on touch and vibration
5.2.0 Kinesthesis
5.2.1 Basic processes and data
5.2.2 Coding and signalling through kinesthesis
5.2.3 Equipment and methods in H.E. research on kinesthesis
5.3.0 Temperature sensitivity
5.3.1 Basic processes and data
5.3.2 Equipment and methods in H.E. research on temperature sensitivity
5.4.0 Smell and taste
5.4.1 Basic processes and data
5.4.2 Olfactory and gustatory signals
5.4.3 Equipment and methods in H.E. research on smell and taste
5.5.0 Pain
5.5.1 Basic processes and data
5.5.2 Equipment and methods in H.E. research on pain

6.0.0 Input channels: choice and interaction

6.1.0 Bibliographies and general references
6.2.0 Comparison of input channels
6.2.1 Comparisons of visual and auditory channels
6.2.2 Comparisons of channels other than visual and auditory
6.3.0 Intersensory effects
6.3.1 Facilitation and inhibition of reception
6.3.2 Factors determining orientation in space

7.0.0 Body measurements; basic physiological capacities; basic motor capacities; and perceptual motor skills

7.1.0 Bibliographies and general references
7.2.0 Anthropometric measurements
7.2.1 Body size, stationary
7.2.2 Body size in motion or in unusual positions
7.3.0 Extent and flexibility of human movement
7.3.1 Extent of limb movement
7.3.2 Flexibility of movement
7.4.0 Equipment and methods in H.E. research on anthropometry
7.5.0 Basic physiological limits in motor performance
7.5.1 Muscular strength and endurance
7.6.0 Basic motor activity
7.6.1 Positioning movements

7.6.2 Repetitive and rhythmic movements
7.6.3 Manual dexterity
7.6.4 Handedness
7.6.5 Involuntary reflexes
7.6.6 Reaction time
7.6.7 Equipment and methods in H.E. research on basic motor activity
7.7.0 Perceptual motor skills
7.7.1 Equipment and methods in H.E. research on perceptual motor skills

8.0.0 Design of controls and integration with displays

8.1.0 Bibliographies and general references
8.2.0 Standardization of controls and their displays
8.3.0 Types of controls
8.3.1 Knobs
8.3.2 Levers and sticks
8.3.3 Pushbuttons
8.3.4 Wheels
8.3.5 Cranks
8.3.6 Handgrip controls
8.3.7 Pedals and rudder bars
8.3.8 Multifunction controls: combined controls
8.3.9 Comparisons among types of controls: choice of control
8.4.0 Coding and labelling of controls
8.4.1 Position
8.4.2 Shape and size
8.5.0 Positioning and plane of operation of controls
8.6.0 Sensitivity and amplification of controls
8.6.1 Movement ratios, precision, and optimum control ratio
8.6.2 Force resistances for specific controls and tasks
8.7.0 Time constants relevant to control operation
8.7.1 Machine constants
For Reaction time — see 7.6.6
8.8.0 Special considerations relating to prolonged adjustments
8.9.0 Integration between display and control

9.0.0 Layout of panels and consoles

9.1.0 Bibliographies and general references
9.2.0 Standardization of panels and consoles
9.3.0 Location of panel relative to operator and task
9.4.0 Grouping of components of panels and consoles
9.4.1 Ease of discrimination
9.4.2 Spatial dynamics
9.5.0 Specific orientation of parts

10.0.0 Design of work space, equipment, and furniture

10.1.0 Bibliographies and general references
10.2.0 Workplace design
10.2.1 Visibility
10.2.2 Ease and speed of movements
10.2.3 Stowage
10.3.0 Furniture specifications
10.3.1 Seating and body support
10.3.2 Seating arrangements
10.3.3 Work surfaces
10.4.0 Passageways, entrances, and exits
10.5.0 Special clothing and personal equipment: effect on work space
10.6.0 Tools
10.7.0 Requirements due to complex motor coordination tasks and special body positions
10.8.0 Design for maintenance
10.9.0 Design for portability in the design of equipment
10.10.0 H.E. evaluations of specific work places and equipments
10.10.1 Cockpits
10.10.2 Airborne equipment
10.10.3 Aircraft
10.10.4 Fire control systems

11.0.0 Clothing and personal equipment

11.1.0 Bibliographies and general references
11.2.0 Clothing ensembles
11.2.1 Thermal protection
11.2.2 Pressure suits
11.2.3 Other types of protective clothing
11.2.4 Fabrics for clothing

11.3.0 Clothing components
11.3.1 Belting
11.3.2 Body armor
11.3.3 Headgear
11.3.4 Handgear
11.3.5 Footgear
11.4.0 Clothing size
11.5.0 Personal equipment
11.5.1 Ear defenders
For Goggles, filters, special glasses, visors — see 3.13.2
11.5.2 Sleeping bags
11.5.3 Packs and carriers
11.5.4 Parachutes, life jackets, and survival equipment
11.5.5 Prosthetics
11.6.0 Effects of combinations of clothing and personal equipment
11.7.0 Shelters
11.8.0 Equipment and apparatus in H.E. research on clothing and personal equipment

12.0.0 Special environmental factors affecting performance

12.1.0 Bibliographies and general references
12.2.0 Thermal environment
12.2.1 Temperature
12.2.2 Humidity
12.2.3 Air velocity
12.2.4 Thermal radiation
12.3.0 Toxic environments
12.4.0 Motion
12.4.1 Speed and acceleration
12.4.2 Vibration
12.4.3 Motion sickness
12.5.0 Altitude and depth
12.5.1 Atmospheric pressure
12.5.2 Oxygen requirements
12.6.0 Nuclear and cosmic radiation
12.7.0 Space travel
For Psychological stress — see 13.2.6
For Factors determining orientation in space — see 6.3.2
For Unusual characteristics of artificial ambient lighting affecting visual performance — see 3.4.4
For Effects of ambient noise and blast on performance — see 4.2.6
12.8.0 Special equipment and methods in studying effects of special environments on performance

13.0.0 Other individual factors, work conditions, and task characteristics that affect behavioral efficiency

13.1.0 Bibliographies and general references
13.2.0 Factors pertaining to the individual
13.2.1 Motivation
13.2.2 Intelligence
13.2.3 Thought processes
13.2.4 Effects of individual understanding of task or set toward task
13.2.5 Span of attention
13.2.6 Psychological stress
13.2.7 Acceptability of equipment and/or task
13.3.0 Factors pertaining to the task
13.3.1 Duration of task
13.3.2 Rest periods
13.3.3 Physical stress or requirements of the task
13.4.0 Effects of physiological factors on performance
13.4.1 Fatigue and behavior decrement
13.4.2 Sleep
13.4.3 Vigilance or alertness
13.4.4 Diet, food, and nutrition
13.4.5 Effects of drugs
13.4.6 Effects of aging

14.0.0 Training aids and devices and their use

14.1.0 Bibliographies and general references

15.0.0 Other areas of psychological research pertinent to human engineering

15.1.0 Personnel psychology relevant to H.E.
15.2.0 Social psychology relevant to H.E.

APPENDIX II

Alphabetical Index to the Human Engineering Literature

Search term	*Code category*
AAF complex coordination test	7.6.7
AN/FPS–3A radar, human engineering evaluation	10.10.2
AN/GRD–9 direction finder set, human engineering evaluation	10.10.2
Abdominal — extension measures	7.2.1
Aberrations	
chromatic	3.15.1
optical	3.15.1
Absolute pitch	4.9.1
Absolute thresholds (see Thresholds)	
Acceleration	
as coding stimulus	5.2.2
effects on performance	12.4.1
measurement of	12.4.1
Accentuation, perceptual	3.15.10
Acceptability	
of equipment	13.2.7
of food	13.4.4
of task	13.2.7
	13.2.4
Access dimensions	10.2.0
Accessibility	
general workplace	10.2.0
stored items	10.2.3
Accident	
prevention	1.5.0
	1.5.1
	1.5.2
probability vs. accident rate	1.5.2
proneness	1.5.0
	1.5.1
	1.5.2
Accident rates	
aircraft	1.5.2
motor vehicle	1.5.1
and noise and blast	4.2.6
and safety aids	1.5.0
Accident records	1.5.0
truck drivers	1.5.1
Accident report form, supervisor	1.5.0
Accident survival	1.5.1
	1.5.2
Accidents, types and causation of	1.5.0
	1.5.1
	1.5.2
Acclimatization	12.2.1
	12.2.2
Accommodation visual	3.15.9
Achromatic color	3.15.4
Achromatopia	3.15.1
Acoustic cues	4.8.1
	4.8.7
Acoustic energy	4.2.0
Acoustic power level measurements	4.2.1
Acoustic shielding	4.2.2

(Estimated total number of such terms = 2200)

Human Factors in Man–Machine Systems

HAROLD E. BAMFORD, JR., Senior Associate, Ritchie and Associates, Inc., Dayton, Ohio; now Senior Group Engineer, Boeing Airplane Co., Seattle, Washington.

The field of human factors is analyzed in an effort to discover its scope and organization. Three orthogonal partitions of the field serve to define eight mutually exclusive, jointly exhaustive, and interdependent sectors. These are considered separately.

Never far from the minds of human factors specialists are such questions as "What is the scope of the human factors profession?" "Just what are the human factors in a man–machine system?" and "What relations exist among them?" The following analysis has proved of value in organizing bibliographic materials, and it is offered here in the hope that it may assist in defining the compass and structure of our new profession.

Whatever the human factors in a man–machine system may be, let us represent them by points in the circular field of the figure. We can immediately divide this field between those factors which affect the job *behavior* of the men who have been incorporated into the system as human components (hereafter referred to as the crew) and those other factors which affect the *condition* of crew and passengers[1]. This is accomplished by the vertical line (Fig. 1).

Next, we can partition the field into three zones, orthogonal to the first two, and containing the *systemic, functional,* and *general* factors, respectively. The systemic human factors are the human utility and cost to the system in its operation. They are thus the concern of high-level system planners, men who are concerned not merely with human factors but with the "big picture."

The general human factors, in contrast, are the province of men who are not primarily concerned with man–machine systems at all, but with men — or more generally, organisms. These factors consist of the behavioral and ecological characteristics of men in general — i.e., apart from any system. They are nevertheless properly included among the human factors in man–machine systems since they characterize potential components, or crew members, of such systems, and potential passengers.

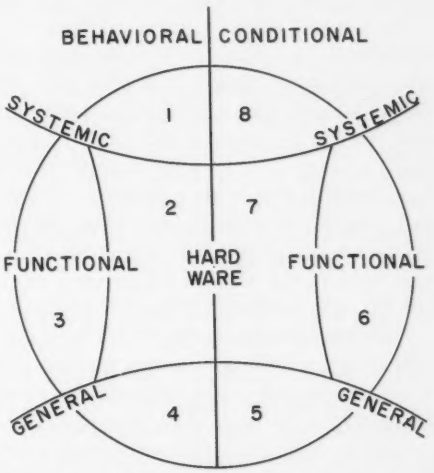


Fig. 1. Partition of human factors field into sectors.

1, Human utility to system. 2, Behavioral characteristics of crew stations. 3, Behavioral demands on crew. 4, Behavioral characteristics of crew. 5, Ecological characteristics of crew. 6, Ecological characteristics of operational environment. 7, Ecological demands on life support system. 8, Human cost to system.

In between the systemic and general human factors lie what we may call, for want of a better name, the functional factors. These include certain functional characteristics of the crew stations and of the system's operational environment, together with their attendant demands on the crew for behavior and on the life support system for ecological support.

Finally, we may divide the functional zone into inner and outer regions. The inner region

[1] This analysis quite frankly follows the paradigm of a vehicular system, but its application is not restricted to systems of that kind. Thus "passengers" may be interpreted as personnel other than crew who are affected by the system's operation.

contains the functional specifications for the equipment with which crew and passengers are to interact — viz., the *crew stations* and the *life support system.* (The life support system is conceived as consisting of all apparatus whose primary purpose is to maintain the mental and physical well-being of crew and passengers.) Hence, it is the province of the human engineer.

This leaves the outer functional zone. On each side of the central partition, the inner and outer regions complement each other. On the conditional side, the outer region contains the ecological characteristics of the system's *operational environment.* The life support system must complement this environment in meeting the ecological demands of crew and passengers. On the behavioral side, the outer region represents the behavior required of the crew members — i.e., their *tasks.* (Tasks are functions of the man–machine system which have been allocated to members of its crew.) Just as the role of the life support system depends upon the ecological characteristics of the operational environment, so do the crew members' tasks depend upon the behavior-relevant characteristics of the crew stations.

By thus partitioning the human factors field we have been able to define eight mutually exclusive and jointly exhaustive sectors. Our analysis concludes with a brief examination of each sector.

SECTOR 1: HUMAN UTILITY TO THE SYSTEM

One of the most fundamental decisions to be made by the planner of a man–machine system is the allocation of its functions between crew and residual system. For any given mission, or required correspondence between the system's output and its environmental input, the functions which are allocated to the crew are those which the latter must perform in order for the system's mission to be realized.

The allocation of sensing, adjusting, and computing functions to the crew involves the establishment of requirements for stimulus and response channels which will permit the allocated sensing and adjusting and the man–machine communication necessary for the allocated computing. This is clearly the case since the stimulus and response channels which are provided for the crew determine which components of the system's input[2] can be sensed by the crew, which components of its output the crew can adjust, and what communications between crew and residual system are possible.

Controls and *indicator displays* are the channels provided for such communication, and the class of possible communications is defined by the relations of *intention* and *designation.* Intention is the functional relation between a control action and the system's output. Designation is the corresponding relation between a display indication and the input which it designates. Thus, a display indication may be said to designate an input, and a control action to intend an adjustment in the system's output.[3] These relations, being abstract, can be defined independently of any particular controls and displays, whose concrete characteristics are among the factors of Sector 2.

Two kinds of gains may be realized by allocating certain of the functions of a man–machine system to its crew: the operational capability, reliability, and availability of the system may be augmented by the use of human components; and through such use net savings may be effected in weight, volume, power, maintenance, and other hardware costs. These gains are the factors of human utility to the system. They are the factors which the system planner must weigh against the corresponding factors of human cost in deciding the complementary roles of man and machine.

SECTOR 2: BEHAVIORAL CHARACTERISTICS OF CREW STATIONS

The concrete characteristics of the objects of a crew station are the factors of Sector 2 — at least insofar as they are behaviorally relevant. Those objects include, besides controls and indicator

[2] A distinction is made between the environmental input to the system and the system's input. The latter includes the environmental input as a component, along with the feedback of the system's output. Thus the input comprises everything sensed by the system.

displays, such other stimulus and response channels as tools, passageways, exits and entrances, optical aids, acoustic aids, printed materials, and the controls and displays of auxiliary equipment. Their factors fall into two classes: general design criteria and detailed design criteria.[4]

The general design criteria are *transitivity* and *interpretability*. The transitivity of a response channel is the degree to which it allows a crew member to select for transmission over it responses which, if carried out, would result in the convergence of the system's actual and required outputs. A stimulus channel's interpretability is measured by the ability of a crew member to interpret the stimuli received over it as signs of the system's actual output in relation to its required output. Transitivity and interpretability subsume such variables as coding and labelling of controls and displays, the positions and planes of movement of controls, and the grouping and orientation of displays and display elements.

Docility and *legibility* are the corresponding criteria for detailed design. The docility of a response channel is measured by the crew member's ability to activate it. Accessibility, portability, traction, and required force are among the factors of docility. Legibility is an attribute of stimulus channels, reflected in the degree to which a crew member is able to discriminate between the different stimuli transmitted over it (without regard to the significance of those stimuli). Scale design, display illumination, magnification, amplification, and signal-to-noise ratio are factors of legibility.

SECTOR 3: BEHAVIORAL DEMANDS ON CREW

The crew members' tasks are defined abstractly by the allocation of functions, which is based on the factors of human utility in Sector 1. The abstractly defined tasks are then made specific by the factors in Sector 2, the behavioral characteristics of the crew stations. They may include such broad categories of behavior as the operation and maintenance of the system and its auxiliary equipment, observation of the system's environment, and the construction of additional facilities.

A more analytical view of these behavioral demands is afforded by Bamford, Hanes, & Wilson.[5] These authors see a crew member's task as consisting always of four generalized task elements: *sensing* or *reading, interpreting, planning,* and *effector action*. The first of these elements, which could be visual, auditory, or of any other modality, imposes the demands of vigilance and acuity. Long- and short-term storage capacity are the demands imposed by interpreting and planning, which are essentially computing functions. And the general requirements of effector action are muscular strength and coordination. These may be imposed on finger, hand, arm, foot, leg, or the apparatus of speech.

SECTOR 4: BEHAVIORAL CHARACTERISTICS OF CREW

It is possible to dichotomize the determinants of behavior between their situational and organismic components.[2] Each of these may in turn be dichotomized: the situational determinants between their social and physical components, and the organismic determinants between components which can be controlled by training and components which cannot be so controlled. Some control over the latter class may be afforded by the selection process.

The physical situational determinant of a crew member's behavior is of course his crew station. The factors of the remaining three components are the human factors of Sector 4. His *selection* and *training* embrace two of the three groupings of this sector. The third grouping comprises the factors of what may be called *group processes and organization*[11] — i.e., the social situational determinants. These last can be controlled to a degree through the selection and training of crew members as social objects, or stimuli, as well as for their roles as subjects, or behavers.

SECTOR 5: ECOLOGICAL CHARACTERISTICS OF CREW AND PASSENGERS

The required behavioral characteristics of the crew are determined by tasks which they must

perform. A crew member is thus a component, incorporated into the system on account of his behavioral characteristics. But there are two sides to the picture. These human beings can perform tasks, but only if their demands for ecological support are satisfied. Those demands, the ecological characteristics of the crew, are the human factors of Sector 5.

A crew member, as an organism, demands an environment many of whose characteristics fall within a quite narrowly restricted range. Beyond that, his environment must support two general classes of ecological interactions (i.e., interactions between the crew member and his environment). For convenience these may be designated the *metabolic* interactions and the *psychological* interactions.[4] The former class subsumes the exchange of materials, such as food, oxygen, carbon dioxide, water and the waste products of metabolism. The psychological interactions are somewhat analogous, stimulation resembling the material input and exercise the material output. Both classes of psychological interactions may be further subdivided into social and physical categories. Interactions with other crew members or passengers would belong to the former class. An example of physical stimulation is the resistance offered by a floor to the force of weight. And locomotion is illustrative of physical exercise.

SECTOR 6: ECOLOGICAL CHARACTERISTICS OF THE OPERATIONAL ENVIRONMENT

The characteristics of the system's operational environment which may affect the condition of its crew and passengers are the human factors of Sector 6. Among these factors eight groupings have achieved a measure of prominence.

The first of these embraces the pressure and chemical composition of the *medium,* which may be either gaseous or liquid. The vacuum of space may be considered a gaseous medium of very low pressure.[1,7,10]

Next is the *acceleration climate.* Both hyponormal and hypernormal accelerative forces have ecological significance. Their directions (relative to the crew members), magnitudes, durations, rates of onset, and frequency are all important.[8,10]

The operational environment may be characterized by *toxicity,* either natural to that environment or incidental to the operation of the system — or the result of an act of war.[10]

Only within a narrow band of *temperatures* is a crew member's survival possible. Still narrower is the range within which his effectiveness as a component is not degraded.[10]

The system's operational environment may be characterized by *radiation.* It may be cosmic or solar in origin, or it may originate in nuclear weapons or in the operation of the system itself. The ecological significance of a radioactive environment is widely recognized.[6]

The principal ecological significance of *moving environmental objects,* such as meteoroids, projectiles, and vehicles, lies in the probability of their collision with the system, and the probability that such an impact would have disastrous consequences. The latter probability is clearly a function both of the medium and of the momentum and explosive propensities of the environmental objects.[13]

Natural ambient lighting is ecologically significant in the effect it may have upon the eyes of a crew member or passenger. Particularly in the operational environment of a spacecraft is environmental luminosity likely to be hazardous.[9,14]

The eighth grouping subsumes the factors of *noise and vibration.* An extensive literature attests to the ecological significance of these factors.[12]

SECTOR 7: ECOLOGICAL DEMANDS ON THE LIFE SUPPORT SYSTEM

Some or all of the ecological characteristics of men which constitute the factors of Sector 5 may be satisfied by the system's operational environment. Upon the life support system devolves the satisfaction of the rest. As we have noted above, the ecological characteristics of the life support system must complement those of the operational environment.

Not only must the life support system make

up for those factors of the operational environment (Sector 6) which provide inadequate ecological support to the crew and passengers, it must also counteract those factors which constitute hazards. A defense must be provided against harmful factors of the medium, against impact, and against the accelerative, toxic, thermal, radiant, luminous, and acoustic and vibratory hazards of the environment. Then the life support system must supply crew and passengers with needed stimulation and the materials of life; it must receive their waste; and it must support their exercise, both physical and social. These requirements are the factors of Sector 7. Formulated as functional specifications or design criteria, they identify this sector as belonging to the domain of the human engineer.

SECTOR 8: HUMAN COST TO THE SYSTEM

The major groupings in this sector are the cost of crew members as components and the cost of crew and passengers as organisms. Under the former heading must be considered the cost of selecting and training the crew. Another factor in that grouping is measured by the value of the alternative utilizations of the crew's manpower which are precluded by its employment in the system. The cost of the crew and passengers as organisms is measured by the limitations on system performance and operational environment imposed by the weight, volume, power requirements, and fragility of crew, passengers, and life support system. This is the cost of ecological support.

DISCUSSION

Without attempting any comprehensive definition, we have defined eight mutually exclusive classes[3] of human factors. If those classes be accepted as jointly exhaustive of the field, we arrive at a general definition, albeit no concise one, and we have answered as well our question as to the scope of the human factors profession. As to the relations which exist among the diverse human factors in a man–machine system, even so brief an examination as we have conducted reveals between the sectors a degree of dependence and organization which fully justi fies our view of the field as unitary.

[3] These classes are second-order divisions of a topical code employed by Ritchie and Associates, Inc., in the organization and analysis of bibliographic material bearing on the operation of manned spacecraft.

REFERENCES

1. ASHE, W. F., WRIGHT, C. C., ANDEREGG, J. W., CARLISLE, H. N., and HAUB, J. G., Historical survey of inhabitable artificial atmospheres. *USAF, WADC Tech. Rep.*, No. 58–154, 1958.

2. BAMFORD, H. E., Some properties of the situational determinants of conceptual behavior. Unpublished doctoral dissertation, University of California, 1953.

3. BAMFORD, H. E., Anticipatory indication, moving display element, and course speed in a continuous compensatory tracking task. Unpublished ms., 1959.

4. BAMFORD, H. E., HANES, L. F., RITCHIE, M. L., and WILSON, S. E., The operation of manned spacecraft. *USAF, WADC Tech. Rep.*, No. 58–225, 1958.

5. BAMFORD, H. E., HANES, L. F., and WILSON, S. E., Missi... for manned military spacecraft. *Human Factors*, **1**, 16, 1959.

6. BARBIERE, R. E., SWEETON, R. F., SAKALOSKY, G. P., and KLATT, P. E., A radiobiology guide. *USAF, WADC Tech. Rep.*, No. 57–118(1), 1958.

7. BERRY, C. A., The environment of space in human flight. *Aeronaut. Engng. Rev.*, **17**(3), 35, 1958.

8. BONDURANT, S., CLARKE, N. P., BLANCHARD, W. G., MILLER, H., HESSBURG, R. R., and HIATT, E. P., Human tolerances to some of the accelerations anticipated in space flight. *USAF, WADC Tech. Rep.*, No. 58–156, 1958.

9. CIBIS, P. A., Retinal adaptation applicable to visual problems in flight at increasing altitudes. In "Physics and Medicine of the Upper Atmosphere," C. S. White and O. O. Benson (Eds.). University of New Mexico Press, Albuquerque, 1952.

10. HITCHCOCK, F. A., Man in space. *News in Engng.*, **30**(4), 18, 1958.

11. SAUL, E. V., Human factors data: their origin, form, classification, and availability. *Proceedings of the National Symposium on Human Factors Systems Engineering*, Philadelphia: HFSA, IRE (Philadelphia Section), and IRE Professional Group on Military Electronics, 1957.

12. TUFTS UNIVERSITY, INSTITUTE OF APPLIED AND EXPERIMENTAL PSYCHOLOGY, HUMAN ENGINEERING ANALYSIS SERVICE, Human Engineering Bibliography. Washington: Dept. Navy, ONR, 1957.

13. WHIPPLE, F. L., Meteoritic phenomenon and meteorites. In "Physics and Medicine of the Upper Atmosphere," C. S. White and O. O. Benson (Eds.). University of New Mexico Press, Albuquerque, 1952.

14. WHITESIDE, T. C. D., The problem of vision in flight at high altitudes. *AGARDograph*, No. 13, 1957.

Directory of Members

ROBERT B. SLEIGHT, Applied Psychology Corporation, Arlington, Virginia.

In September, 1957 the Human Factors Society held its Constitutional Convention in Tulsa, Oklahoma. Approximately 90 persons attended this first national meeting. By March of 1958, membership had grown to 283. By August, 1959, the membership stood at 457.

Along with the Society's rapid growth there has been a lively movement of members who have changed their affiliations or who have been reassigned within their own organizations. In the period between mid-April and mid-July, 1959, address changes occurred at the rate of 30% of the membership annually.

The Membership Committee has attempted to establish a complete and useful directory for the benefit of individual members, regional affiliates of the Society, and for the Society as a whole. After several postponements to assure the best possible coverage, a cut-off date of August 31, 1959 was established. For approximately 28 percent of the membership, only names and addresses are available.

The information is listed in the following manner: Name, mail address; highest degree, year received (field); job title, department, company, address; primary professional training; human factors interests.

Following the personal information given in this alphabetical list of members is a geographical recapitulation of membership by country or state.

ADAMS, BERTRAM B., 10542 La Dona Dr., Garden Grove, Calif.; A.B. & Graduate Study, 1954 (Psychology); Human Factors Engineer, Human Factors Engineering, Dept. 495-23, Missile Div., North American Aviation, Inc., 12214 Lakewood Blvd., Downey, Calif.; Trng.—Human Factors in Weapon System Development; Int.—Weapon System Analysis & Personnel Subsystem Development.

ADAMS, OSCAR S., 2121 Ponce de Leon Ave., N.E., Atlanta 7, Ga.; Ph.D. 1952 (Psychology); Human Factors Research Specialist, Human Factors Research, Dept. 72-08, Lockheed Aircraft Corp., Marietta, Ga.; Trng.—Experimental psychology; Int.—Variables affecting prolonged human performance.

ADELSON, MARVIN, 1106 West Ave., Fullerton, Calif., Ph.D. 1952 (Psychology); Head, Man-Mission Analysis Section, Systems Analysis Dept., Ground Systems Group, Hughes Aircraft Co., P. O. Box 2097, Fullerton, Calif.; Int.—Information flow & decisions.

ALEXANDER, LAWRENCE T., 11833 Allaseba Dr., Los Angeles, Calif.; Ph.D. 1950 (Psychology); Assistant Director for Research, Human Factors Directorate, System Development Corp., 2500 Colorado Ave., Santa Monica, Calif.; Trng.—Psychology (Experimental; Physiological); Int.—Learning; systems design; systems training.

ALEXANDER, MILTON, P. O. Box 291, Fairborn, Ohio; B.A. 1953 (Anthropology); Project Engineer, Anthropology Section, Bio-Physics Branch, Aero-Medical Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio; Trng.—Physical anthropology in human engineering; Int.—Personal equipment design & sizing.

ALLISON, BYRON L., 3930 Sturdevant, Davenport, Iowa; Product Mgr., Oxygen Equipment, Pioneer Central Division, Bendix Aviation Corp., Davenport, Iowa; Trng.—Engineering-physics; Int.—Instrumentation & data presentation.

AMES, SMITH W., 5000 Mc Neer St., Mc Lean, Va.

ANDERSON, LT. COL. GEORGE R., 805 W. 31st Ave., Bellevue, Nebr.; M.D. 1949 (Medicine); Chief of Aviation Medicine Branch, Office of the Surgeon, Hq., Strategic Air Command, Offutt A.F.B., Nebraska; Trng.—Aviation medicine; Int.—Aeromedical aspects of human-machine integration.

ANDREWS, F. G., 10376 Oletha Lane, Los Angeles 24, Calif.

ANSON, WILLIAM H., Human Factors Section, The Martin Co., Baltimore 3, Md.

ARCHIBALD, CAPT. ERWIN R., P. O. Box 926, Holloman A.F.B., New Mexico; Ph.D. (Adv. to Candidacy) 1955 (Physiology); Research Aviation Physiologist, Aeromedical Field Laboratory, Air Force Missile Development Center, Holloman Air Force Base, New Mexico; Trng.—Physiology and chemistry; Int.—Sealed cabins; environmental stress; respiratory physiology.

ARNOLD, JOHN E., Mech. Engr. Dept., Stanford University, Palo Alto, Calif.

ASSELIN, N. D., 95 Millers Lane, Kingston, N.Y.

ATKINS, DALE L., 11006 Gloria Ave., Granada Hills, Calif.; B.A. 1958 (Psychology); Research Engineer, Systems Engineering Div.; Radioplane, Division of Northrup, 8000 Woodley Ave., Van Nuys, Calif.; Trng.—Human factors engineering; Int.—Presentation of information & equipment maintainability.

ATKINS, DAVID W., 19840 Acre St., Northridge, Calif.; M.A. 1952 (Psychology); Research Engineer, Human Engineering Section, Litton Industries, 336 North Foothill Rd., Beverly Hills, Calif.; Trng.—Psychology; Int.—Systems analysis, layout and design.

BAMFORD, HAROLD E., JR., 4502 E. 70th, Seattle, Wash.; Ph.D. 1953 (Psychology); Senior Group Engineer, Systems Management Office, Boeing Airplane Co., Seattle, Wash.; Trng.—Experimental psychology; Int.—man-machine relations in astronautical systems.

BARBER, JACOB L., JR., 217 Virginia Hills Ave., Alexandria, Va.; M.A. 1948 (Psychology); Research Psychologist, U.S. Army Engineer Research & Development Laboratories, Fort Belvoir, Va.; Trng.—Psychology, physics, mathematics; Int.—System studies and design.

BARKER, HERBERT, JR., NYADS, Sage Bldg., McGuire A.F.B., Trenton, N.J.; B.A. 1954 (Anthropology); Human Factors Specialist, System Development Corp., SAGE Field Training Operations Grp., 2400 Colorado Ave., Santa Monica, Calif.; Trng.—Anthropometry, statistics, workspaces, kinesiology, system of component training; Int.—Systems analysis & training, data reduction, human factors.

BARKER, WILLIAM S., 507 So. 18th St., Arlington, Va.; Ph.D. 1951 (Psychology); Senior Research Scientist, Vice President Psychological Research Associates, Inc., 507 So. 18th St., Arlington 2, Va. Trng.—Experimental psychology; Int.—System analysis, training devices, human engineering.

BARNES, KISCHEL M., 750 Greentree Rd., Pacific Palisades, Calif.; Manager, Flight Safety Acc. Division, Hardman Tool & Engineering Co., 1845 So. Bundy Dr., Los Angeles 25, Calif.; Trng.—Pilot, crash protection, flight safety; Int.—Aviation crash protection & prevention, military & commercial.

BARRON, CHARLES IRWIN, 19303 Itasca, Northridge, Calif.; M.D. 1942 (Medicine); Medical Director, California Division, Lockheed Aircraft Corp., Burbank, Calif.; Trng.—Medicine; Int.—Aviation & space medicine.

BAXTER, J. RUSSELL, 79 Bowen St., Chadstone, Vic. Australia; B.E. 1947 (Aeronautics); Senior Scientific Officer, Aeronautical Research Laboratories, Department of Supply, Box 4331, G.P.O. Melbourne, Vic. Australia; Trng.—Engineering; Int.—Pilot judgment problems (particularly during landing).

BEAM, R. ATLEE, 3039 Fashion Ave., Long Beach, Calif.

BEAUPEURT, JOSEPH E., 541 N. Belmont, Wichita 6, Kansas; Chief, Human Factors Group, Wichita Divi-

sion, Boeing Airplane Co., Wichita, Kansas; Trng.—Design engineering; Int.—Aero-space engineering, human factors requirements.

BEHAN, RICHARD A., c/o Ramo-Wooldridge Corp., Ramo Wooldridge Rd., Denver, Colo.; Ph.D. 1955 (Psychology); Human Factors Scientist, Ramo-Wooldridge Corp., Ramo Wooldridge Rd., Denver, Colo.; Trng.—Experimental psychology; Int.—Human factors in data processing systems.

BEKEY, GEORGE A., 989 Vernon Ave., Venice, Calif.; M.S. 1952 (Engineering); Member of Technical Staff, Controls & Simulation Dept., Space Technology Laboratories, Inc., P. O. Box 95001, Los Angeles 45, Calif.; Trng.—Electrical engineering, controls, computers; Int.—Physiology, man-machine systems.

BENNETT, CORWIN A., 12 Devon Dr., R.D. 1, Endicott, N.Y.; Ph.D. 1954 (Psychology); Manager, Human Factors, Military Products Division, International Business Machines Corp., Owego, N.Y.; Trng.—Experimental psychology; Int.—Human data processing & systems analysis.

BENNETT, WILLIAM F., 1216 State St., Santa Barbara, Calif.

BERANEK, LEO L., 50 Moulton St., Cambridge 38, Mass.; Sc.D.-Harvard 1940 (Physics); President, Bolt, Beranek and Newman, Inc., 50 Moulton St., Cambridge 38, Mass.; Trng.—Acoustics, psychoacoustics; Int.—Controls, displays, psychophysics, artificial intelligence, man-machine systems.

BERRIDGE, HAROLD L., 411 Hollywood Blvd., Ft. Walton Beach, Fla., Ed.S. 1948 (Educational Administration, Psychology); Chief, Air Defense & Tactical Branch, Human Factors Office, Air Proving Ground Center, Eglin A.F.B., Fla.; Trng.—Health, physical education, educational administration, psychology.

BERRY, HERBERT A., 14639 S. Los Fuentes Rd., La Mirada, Calif.; Ed.D. 1954 (Education); Human Factors Engineer (Design Specialist), Commercial Transport (Long Beach) Division, Douglas Aircraft Co., Long Beach, Calif.; Trng.—Applied psychology; Int.—Control dynamics, design of displays.

BIEL, WILLIAM C., 2500 Colorado Ave., Santa Monica. Calif.; Ph.D. 1937 (Psychology); Vice President, System Development Corp., 2500 Colorado Ave., Santa Monica, Calif.; Trng.—Psychology, experimental & physiological; Int.—Human-factors-in-systems.

BLANCHARD, DR. WILLIAM H., 11937 Hart St., Apt. A, No. Hollywood, Calif.; Ph.D. 1954 (Psychology); Human Factors Scientist, System Training Operations Dept., System Development Corp., 2400 Colorado Blvd., Santa Monica, Calif.; Trng.—Clinical psychology; Int.—System training, design and development.

BLOCKLEY, W. VINCENT, 130 Ocean Way, Santa Monica, Calif.; B.A. 1943 (Physiology); Supervisor, Physiology, Human Factors Group, Engineering, North American Aviation, Inc., Los Angeles 45, Calif.; Trng.—Environmental physiology; Int.—Thermal tolerance, environmental control, psychomotor performance.

BLOOM, AARON, 1431 N. Harding Ave., Pasadena, Calif.; B.S. 1939 (Aero Engineering); Vice President, Engineering, Sierra Engineer Co., 123 E. Montecito Ave., Sierra Madre, Calif.; Trng.—Engineering; Int.—Safety equipment & medical surgical devices.

BOND, NICHOLAS A., JR., 4432 Don Miguel Dr., Los Angeles 8, Calif.; Ph.D. 1955 (Psychology); Associate Psychologist, Dunlap & Associates, 1532 3rd St., Santa Monica, Calif.

BOSTROM, KARL A., 133 West Oregon St., Milwaukee, Wisconsin.

BOWEN, GEORGE W., 173 W. Poplar St., Floral Park, N.Y.

BRANDALISE, BOB B., 3547 Colorado, N.E., Albuquerque, N.M.; M.A. 1957 (Psychology); Human Factors Specialist, Division 1592, Sandia Corp., Sandia Base, Albuquerque, N.M.; Trng.—Experimental psychology; Int.—Perception, motor skills, psychophysics.

BRANNAN, MAX, Metropolitan State Hospital, 11400 S. Norwalk Blvd., Norwalk, Calif.

BRIGGS, STEWART J., 1687 Chateau, Anaheim, Calif.; Ph.D. 1955 (Psychology); Human Factors Engineer, Dept. 2221, Nortronics, Systems Support, 500 E. Orange Thorpe, Anaheim, Calif.; Trng.—Industrial psychology; Int.—Electronic maintainability, fire control, systems support.

BROWN, D. W., Box 45481, Airport Station, Los Angeles 45, Calif.

BRYAN, G. L., University of Southern Calif., Electronics Personnel Research Group, Los Angeles 7, Calif.

BUCKNER, DONALD N., 1112 Crenshaw Blvd., Los Angeles 19, Calif.; Ph.D. 1959 (Psychology); Vice President and Project Director, Human Factors Research, Inc., 1112 Crenshaw Blvd., Los Angeles 19, Calif.; Trng.—Experimental psychology; Int.—Experimental psychology, human performance, performance, criteria.

BURGESS, GEORGE G., HRB-Singer, State College, Pa.; HRB-Singer, State College Pa.; Ph.D. 1957 (Psychology); Senior Psychologist, HRB-Singer, State College, Pa.; Trng.—Industrial psychology; Int.—QPRI, High speed computers.

BUSHONG, CAPT. ALBERT J., 710 Chinquapin Dr., Eglin A.F.B., Fla., M.A. 1958 (Psychology); Research Psychologist, Human Factors Office, Hq. APGC (ARDC), USAF, Eglin A.F.B., Fla.; Trng.—Experimental psychology; Int.—Operational & engineering (aeronautical) evaluation.

CACIOPPO, ANTHONY J., 2600 Overbrook Rd., Cuyahoga Falls, Ohio; Ph.D. 1954 (Sociology/Psychology); Head, Biomechanical Engineering Section, Avionics and Electronics Division, Goodyear Aircraft Corp., Akron, Ohio; Trng.—Behavioral and physical sciences; Int.—Behavioral models, response dynamics, space flight.

CAREL, WALTER L., 503 Warren Rd., Ithaca, N.Y.; B.A. 1949 (Psychology); Consulting Specialist-Human Factors; Advanced Electronics Center, LMEE, General Electric Co., Ithaca, N.Y.; Trng.—Psychology; Int.—Crew functions, airborne & space avionics.

CAROTHERS, O. E., 504 W. Ellis Ave., Inglewood, Calif.

CARRIGER, MRS. BARBARA K., Box 1362, Sierra Vista, Ariz.; B.A. 1951 (Psychology); Affiliated with Electronic Warfare Dept., U.S. Army Proving Ground, Fort Huachuca, Ariz.; Trng.—Psychology; Int.—Social perception and cognition, group interaction.

CARSTATER, EUGENE D., 606 Jackson Dr., Falls Church, Va.; Ph.D. 1937 (Education and Educational Psychology); Training Research Advisor (Civil Service Series GS-1710), Personnel Research Division, Bureau of Naval Personnel, Navy Dept., Washington 25, D.C.; Trng.—Education; Int.—Technological impact on human resources.

CART, HUGH, Box 481, Boron, Calif.

CARTER, CHARLES W., 6830 Delaware Ave., La Mesa, Calif.; B.S. 1940 (Mechanical Engineering); Senior Design Engineer, Equipment Design, Convair-Div. of General Dynamics Corp., San Diego 12, Calif.; Trng.—Mechanical engineering—design & development; Int.—Integration of human factors into applied design.

CARTER, LAUNOR F., 249 Mantua Rd., Pacific Palisades, Calif.; Ph.D. 1941 (Psychology); Director of Human Factors, General Manager of System Training, Human Factors Directorate, System Development Corp., 2500 Colorado Ave., Santa Monica, Calif.; Trng.—Psychology; Int.—Leadership, administrative behavior, simulation.

CARTER, ROBERT E., 101 Apple Dr., Greencastle, Pa.; B.A. 1938 (Zoology); Operations Analyst (Human Engineer), Operations Analysis, Fairchild Aircraft & Missile Div., Hagerstown, Md.; Trng.—Aircraft & missiles; Int.—Product design, control systems, and maintenance.

CATRAN, JACK, 8758 Sophia, Sepulveda, Calif.; M.A. 1946 (Engineering-Industrial Design); Director-Human Factors & Organization Design, Marquardt Aircraft Co., Van Nuys, Calif.; Trng.—Industrial design-psychology; Int.—Design of weapons & organization systems—equipment & physiology.

CELENTANO, JOHN T., 1220 W. 37th St., Los Angeles 7, Calif.

CHAFFEE, JOHN W., 3504 Wedgway Dr., Ft. Worth, Texas; B.A. 1952 (Physical Anthropology); Design Engineer (Human Factors), Human Factors Lab., Furnishings Group, Engineering Dept., Fort Worth Division, Convair, Ft. Worth, Texas; Trng.—Anthropometry, human kinematics; Int.—Anthropometrics, ergonomics, body-kinematics, statistics.

CHALMERS, E. LAURENCE, JR., 2102 Croydon Dr., Tallahassee, Fla.; Ph.D. 1951 (Psychology); Associate Professor, Dept. of Psychology, Florida State University, Tallahassee, Fla.; Trng.—Experimental Psychology; Int.—Component skills analysis, training, and proficiency measurement.

CHAPANIS, ALPHONSE, Dept. of Psychology, The Johns Hopkins University, Baltimore 18, Md.; Ph.D. 1943 (Psychology); Professor of Psychology & Industrial Engineering, Depts. of Psychology & Industrial Engineering, The Johns Hopkins University, Baltimore 18, Md.; Trng.—Psychology; Int.—Teaching, research, consulting, engineering psychology.

CHAPIN, R. G., 4815 Lee St., Torrance, Calif.

CHEATHAM, PAUL G., Office of Naval Research, Code 455, Washington 25, D.C.; Ph.D. 1949 (Psychology); Assistant Branch Head, Engineering Psychology Branch, Office of Naval Research, Washington 25, D.C.; Trng.—Experimental psychology; Int.—Visual displays, information handling.

CHRISTENSEN, JULIEN M., 1422 Haft Dr., Reynoldsburg, Ohio; M.A. 1951 (Psychology); Chief Engineering Psychology Branch, Aero Medical Laboratory, Wright Air Development Center, Wright-Patterson A.F.B., Ohio; Trng.—Experimental Psychology; Int.—Systems research and analysis; displays; controls.

CHRISTENSEN, PAUL R., 1551 Gates Ave., Manhattan Beach, Calif.

CHRISTIAN, JOHN F., 195 Willoughby Ave., Brooklyn 5, N.Y.; B.S. 1950 (Engineering); Trng.—Fire equipment design; Int.—Combat equipment.

CHRISTNER, CHARLOTTE A., 505 King Ave., Columbus, Ohio; Ph.D. 1957 (Psychology); Project Leader, Systems Engineering Division, Battelle Memorial Institute, 505 King Ave., Columbus, Ohio; Trng.—Experimental Psychology; Int.—Visual display systems; automation; multiple operators.

CLEGG, DONALD A., 731 Roberto Ave., Santa Barbara, Calif.; M.A. 1953 (Experimental Psychology); Operations Research, Technical Military Planning Operation (TEMPO), General Electric Co., 735 State St., Santa Barbara, Calif.; Trng.—Experimental Psychology.

COBURN, RICHARD, 2018 Catalina Blvd., San Diego 7, Calif.; M.A. 1952 (Education); Head, Man-Machine Section, U.S. Navy Electronics Laboratory, San Diego 52, Calif.; Trng.—Education and electronic engineering; Int.—Visual displays and man-computer communication.

COHEN, HAROLD L., 515 No. Oakland, Carbondale, Ill.; B.A. 1959 (Product Design); Chairman, Dept. of Design, School of Fine Arts, Southern Illinois University, Carbondale, Ill.; Trng.—Product-shelter designer; Int.—Autonomous shelter, bio-equipment, orthetics, seating.

COLBERT, CHARLES, P. O. Box 263, Yellow Springs, Ohio; B.E.E. 1940 (Electrical Engineering); President-Consulting Engineer, Westgate Laboratory, Inc., P. O. Box 63, Yellow Springs, Ohio; Trng.—Electronics; Int.—Training devices, control panels, displays.

COLLIER, DOUGLAS R., JR., 15651 Superior St., Sepulveda, Calif.; M.D. 1951 (Aviation Medicine); Flight Surgeon, Lockheed Medical Dept., Lockheed Aircraft Corp., Burbank, Calif.; Trng.—Medicine.

COLLINS, LLOYD R., Code 2134, U.S. Navy Electrical Lab., San Diego 52, Calif.; M.S. 1951 (Anthropology); Physical Anthropologist, Human Factors Division, U.S. Navy Electronics Laboratory, San Diego, Calif.; Trng.—Anthropology, psychology, and physiology; Int.—Maintenance of electronic systems and equipment design.

COLMAN, KENNETH W., 1711 Walnut, Philadelphia 3, Pa., M.S. 1953 (Experimental Psychology); Program Director-Vice President, Courtney & Co., Inc., 1711 Walnut St., Philadelphia 3, Pa.; Trng.—Experimental Psychology; Int.—Human engineering, simulation, training devices, audio-visual techniques, aviation.

COLSON, KENNETH R., 1262 Allen Ave., Glendale, Calif.; M.S. 1956 (Psychology); Human Factors Engineer, Nortronics Systems Support, 500 Orangethorpe, Anaheim, Calif.; Trng.—Industrial Psychology; Int.—Training and equipment design.

CONKLIN, JACK E., 1323 Palisades Beach Rd., Santa Monica, Calif.; Ph.D. 1954 (Experimental Psychology); Human Factors Scientist, Operational Design Group, System Development Corp., 2500 Colorado Ave., Santa Monica, Calif.; Trng.—Experimental psy-

chology, statistics, human engineering; Int.—Research, man-machine systems, perception.

CONOVER, DONALD W., 1850 Montecito Way, San Diego 3, Calif.; Ph.D. 1955 (Psychology); Convair, Division General Dynamics, San Diego, Calif.; Trng. —Industrial engineering & experimental psychology; Int.—Operations research and experimental design.

CONTINI, RENATO, 7 Peter Cooper Rd., New York 10, N.Y.; B.S. 1924 (Aeronautics); Senior Research Scientist-Research Coordinator, Research Division, College of Engineering, New York University, University Heights, New York 53, N.Y.; Trng.—Aeronautical engineering; Int.—Biomechanics.

COOPER, J. I., 444 Calle Mayor, Torrance, Calif.

COOPER, WILFRED N., 1821½ Westmoreland Ave., Los Angeles 6, Calif.

CORNOG, DOUGLAS Y., 2802 74th Ave., Apt. 201, Hyattsville, Md.; M.S. 1953 (Industrial Psychology); Trng.—Industrial Psychology; Int.—Systems research, anthropometry, personnel selection-training.

CORNWALL, ELLSWORTH W., 15312 Whitfield Ave., Pacific Palisades, Calif.; B.S. 1937 (Mechanical Engineering & Space Development, Douglas Aircraft Co., 3000 Ocean Park Blvd., Santa Monica, Calif.; Trng.— Air conditioning work on piloted aircraft; Int.—Environmental condition, problems related to vehicle thermodynamics.

CORSO, JOHN F., Dept. of Psychology, Pennsylvania State University, University Park, Pa.; Ph.D. 1950 (Experimental Psychology); Professor of Psychology, Dept. of Psychology, Pennsylvania State University, University Park, Pa.; Trng.—Experimental Psychology; Int.—Audition, engineering psychology, research design/administration.

COULES, JOHN, 8 Lucy St., Stoneham 80, Mass.; Ph.D. 1953 (Psychology); Research Psychologist, Operational Applications Laboratory (CRES), Air Force Cambridge Research Center, L. G. Hanscom Field, Bedford, Mass.; Trng.—Experimental Psychology; Int.—Visual displays, man-machine systems.

COURTNEY, DOUGLAS, 1711 Walnut St., Philadelphia 3, Pa., Ed.D. 1949 (Psychology); Director, Courtney & Co., Inc., 1711 Walnut St., Philadelphia 3, Pa.; Trng.—Psychologist; Int.—Systems analysis & design, emphasis human component.

CUMMING, RONALD W., 83a Centre Rd., Brighton S.6., Victoria, Australia (temporary address until August 1960; 502 E. Kingsley, Ann Arbor, Michigan); B.E. 1941 (Aeronautical Engineering); Principal Scientific Officer, Human Engineering Group, Aeronautical Research Laboratories, Dept. of Supply, G.P.O. Box 4331, Melbourne, Australia; Trng.— Aeronautical Engineering; Int.—Human factors research in aeronautics.

CUNNINGHAM, CLAIRDON E., 3628 Charles St., San Diego 6, Calif.; B.S. 1941 (Psychology); Head, Systems Maintainability Section, Human Factors Division, U.S. Navy Electronics Lab., San Diego 52, Calif.; Trng.—Physiological Psychology; Int.—Human factors in electronic systems maintenance.

CUTTING, RALPH C., JR., 44 Stone Road, Belmont 78, Mass.

DAMON, ALBERT, Homer St., Newton, Mass.; Ph.D. 1946, M.D. 1951 (Human Development, Physical Anthropology); Asst. Professor of Medical Anthropology, Dept. of Industrial Hygiene, Harvard School of Public Health, 1 Shattuck St., Boston 15, Mass.; Trng.—Physical Anthropology, Internal Medicine; Int.—Anthropometry, personnel selection, internal medicine.

DANAHER, JAMES W., Park Towne North, N104, 2200 Benj. Franklin Pkwy., Philadelphia 30, Pa.; M.A. 1958 (Experimental Psychology); Research Associate, Courtney & Co., Inc., 1711 Walnut St., Philadelphia 3, Pa.; Trng.—Experimental Psychology, Naval Aviator; Int.—Aviation and air traffic control.

DANIELS, FARRINGTON, JR., 3181 S.W. Jackson Park Rd., Portland 1, Ore.; M.D. 1943 (Medicine); Asst. Professor, Division of Dermatology, University of Oregon Medical School, 3181 S.W. Jackson Park Rd., Portland 1, Ore.; Trng.—Medicine; Int.—Applied physiology, skin reactions to environment.

DAVIS, HARRY L., Industrial Engineering Div., Kodak Park, Eastman Kodak Co., Rochester, N.Y.; B.S. 1950 (Engineering); Technical Advisor, Industrial Engineering, B-56, Eastman Kodak Co., Kodak Park, Rochester, N.Y.; Int.—General.

DAVIS, ROBERT A., Philco Corp., 806 Chestnut St., Redwood City, Calif.

DAVIS, ROBERT H., 6181 Valleyview, Littleton, Colo.

DEAN, EDWARD L., 317 28th St., Manhattan Beach, Calif.; B. Aero E. 1951 (Aero Engineering); Research Engineer, Human Factors, Los Angeles Division, North American Aviation, International Airport, Los Angeles 45, Calif.; Trng.—Aeronautical engineer, psychology; Int.—Cockpit design & research.

DE BONS, LT. COL. ANTHONY, Box 366, Griffiss A.B., N.Y.; Ph.D. 1954 (Experimental Psychology); Asst. Director, Directorate of Technical Services, Rome Air Development Center, U.S.A.F., Griffiss A.F.B., N.Y.; Trng.—Experimental Psychology; Int.—Human engineering, vision, unusual environments.

DEMBNER, ELLIOT, 971 Utica Ave., Brooklyn 3, N.Y.; B.M.E. 1958 (Mechanical Engineering); Associate Research Scientist & Instructor, Engineering Mechanics, College of Engineering & Research Division, New York University, New York 53, N.Y.; Trng.— Prosthetics & Orthotics; Int.—Bio-mechanics.

DETAMBEL, MARVIN H., 2507 E. Commonwealth Ave., Fullerton, Calif.; Ph.D. 1953 (General & Experimental Psychology); Head, Projects Group, Man-Mission Analysis Section, Systems Analysis Dept., Ground Systems Group, Hughes Aircraft Co., Fullerton, Calif.; Trng.—General & Experimental Psychology; Int.—Systems analysis, equipment design, research.

DE TOGNI, GINO R., 15 Nynderse St., Schenectady 6, N.Y.; B.S. 1951 (Physics); General Engineer (Human Engineering), Research & Engineering Div., Watervliet Arsenal, Watervliet, N.Y., Trng.—Time & motion study; Int.—Blast, safety, physical forces, environmental testing.

DEVOE, DR. DONALD B., 44 MacArthur Rd., Stoneham 80, Mass.; Ph.D. 1952 (Psychology); Research Psychologist, Operational Applications Laboratory, Air Force Cambridge Research Center, L. G. Hanscom Field, Bedford, Mass.; Trng.—Psychology; Int.— Human engineering, systems, displays, perception.

DICKEY, FRANK L., 4153 So. New Haven Pl., Tulsa, Okla.; B.S. 1937 (Mechanical Engineering); Chief, Interiors Design, Douglas Aircraft Co., Tulsa Divi-

sion, Tulsa, Okla.; Trng.—Engineering; Int.—Engineering applications in aircraft and spacecraft.

DITTMAN, PAUL E., 1955 Sunset Dr., Seattle 16, Wash.; M.S. 1950 (Psychology); Asst. Manager Human Factors Branch, Systems Management Office, Boeing Airplane Co., Seattle 66, Wash.; Trng.—Psychology; Int.—Human engineering & training.

DOMEY, RICHARD, 2361-A Massachusetts Ave., Lexington 73, Mass.

DOUGHERTY, DORA J., 2805 Mimosa Park, Ft. Worth 18, Texas.

DOUGLAS, RILEY E., JR., 4932 Calderon Rd., Woodland Hills, Calif.; M.A. 1956 (Anthropology); Sr. Human Factors Specialist, Training Development Branch, System Development Corp., 2400 Colorado Ave., Santa Monica, Calif.; Trng.—Anthropology; Int.—Man-machine systems interrelationships.

DOUGLAS, W. A., 2656 N. Pasadena Ave., Los Angeles 31, Calif.

DRILLIS, RUDOLFS J., 88 Prospect Park West, Brooklyn 15, N.Y.; Ph.D. 1931 (Applied Psychology); Senior Research Scientist, Research Division, College of Engineering; New York University, University Heights, New York 53, N.Y.; Trng.—Industrial Engineering & Applied Psychology; Int.—Work science, biomechanics, psychomotorics.

DUDDY, JOHN H., III, 412-4900 Battery Lane, Bethesda 14, Md.

DUNCAN, RICHARD, D. P., 440 Great Rd., Bedford, Mass.; B.S. 1952 Psychology; B.S.M.E. 1958 (Mechanical Engineering); Research Engineer, Applied Sciences Division, Research Dept., Melpar, Inc., 43 Leon St., Boston, Mass.; Trng.—Psychology & Mechanical Engineering; Int.—general.

DUNLAP, JACK W., 429 Atlantic St., Stamford, Conn.; Ph.D. 1931 (Psychology & Agricultural Economics); President, Dunlap & Associates, Inc., 429 Atlantic St., Stamford, Conn.; Trng.—Systems studies & operations research.

ECKENRODE, ROBERT T., 4 Arbor Court, So. Norwalk, Conn.; B. Ch. E. 1951; Senior Systems Engineer, Dunlap & Associates, Inc., 429 Atlantic St., Stamford, Conn.; Trng.—Engineering Psychology; Int.—Man-machine analysis and requirements studies.

ELKIND, J. I., DR., 50 Moulton St., Cambridge, Mass.

EPSTEIN, SIDNEY, DR., P. O. Box 261, Lodi, N.J.

ERSKINE, DONAL G., 5103 Whiteford Ave., Baltimore 12, Md.; Principal Industrial Designer Head, Human Factors Group, Dept. 461, Bendix Radio Div., Bendix Aviation Corp., E. Joppa Rd., Baltimore 4, Md.; Trng.—Industrial Design; Int.—Task analysis, training, simulation, maintenance.

ESCH, LYND J., 11642 Nearing Dr., Anaheim, Calif.; Ph.D. 1953 (Anthropology); Engineering Specialist—Human Factors, Nortronics Div., Northrup Corp., 222 N. Prairie Ave., Hawthorne, Calif.; Trng.—Anthropology & Engineering; Int.—Design of controls and control areas.

ESTRINE, LEWIS, 45 Puritan Lane, Stamford, Conn.; M.A. 1950 (Psychology); Associate Engineering Psychologist, Dunlap & Associates, Inc., 429 Atlantic St., Stamford, Conn.; Trng.—Psychology; Int.—Human engineering, systems analysis, training.

EVANS, WILLIAM E., 22845 Burton St., Canoga Park, Calif.

EWING, RONALD W., HRB-Singer, Inc., Circleville Rd., Science Park, State College, Pa.; B.S. 1959 (Electrical Engineering); Psychologist, Human Factors Section, HRB-Singer, Inc., Circleville Rd., Science Park, State College, Pa.; Trng.—Human Engineering; Int.—Human factors research and design.

FARNSWORTH, CDR. DEAN. Box 39, Navy 100, F.P.O., New York, N.Y.; M.A. 1929; M.A. 1942 (Psychology); Scientific Liaison Officer, Office of Naval Research, U.S. Navy; Trng.—Psychology; Int.—Habitability, illumination, color, vision.

FARRIS, HERBERT J., 105 W. 113th St., Kansas City, Mo.; M.A. 1954 (Education); Human Factors Specialist, System Development Corp., 2500 Colorado St., Santa Monica, Calif.; Trng.—Education; Int.—Training in man-machine relationships.

FAUBION, COL. RICHARD W., 203 So. Gilbert St., Anaheim, Calif.; B.A. 1924 (Psychology); Supervisor Human Factors Engineering Staff, Missile Division, North American Aviation, Inc., 12214 Lakewood Blvd., Downey, Calif.; Trng.—Aviation Psychologist; Int.—Human engineering, operations and systems analysis.

FERGUSON, L. G., 1177 Galloway St., Pacific Palisades, Calif.; Senior Design Engineer, Engineering Dept., Human Factors Group, North American Aviation, Inc., L. A. Division, Los Angeles 45, Calif.; Trng.—Aeronautical Engineering; Int.—Escape systems.

FERWERDA, GERALD J., 130 W. Lexington Ave., Milwaukee 17, Wis., B.S. 1950 (Electrical Engineering); Human Factors Representative, Dept. 32-29, A.C. Spark Plug Division, G.M.C., Milwaukee 1, Wis.; Trng.—Electronics & Industrial Engineering; Int.—Human engineering, inertial guidance systems.

FIGHTMASTER, WALTER J., 1443 Putty Hill Rd., Baltimore 4, Md., M.A. 1954 (Industrial Psychology); Senior Engineer, Human Factors, Missile & Electronics Div., The Martin Co., Baltimore 3, Md.; Trng.—Industrial-Engineering Psychology; Int.—System & task analyses, anthropometry and layout.

FINK, JOHN B., Martin Co., Space Medicine Sect., P. O. Box 179, Denver, Colo.; Ph.D. 1953 (Psychology); Human Factors Specialist, Head Psychology & Human Engineering Unit, Space Medicine Section, Martin Co., P. O. Box 179, Denver, Colo.; Trng.—Experimental Psychology; Int.—Physiological and behavioral man-machine interactions.

FINK, JOSEPH, 2500 Colorado Ave., Santa Monica Calif.; Ph.D. 1956 (Psychology); Human Factors Scientist, System Development Corp., 2500 Colorado Ave., Santa Monica, Calif.; Trng.—Psychology; Int.—System training, space research.

FINKELSTEIN, STANLEY, 20047 Weyher, Livonia, Mich. B.S. 1954 (Aeronautical Engineering); Human Factors Analyst, Field Test Dept., Chrysler Corp., Missile Div., P. O. Box 2628, Detroit 31, Mich.; Int.—Environmental testing and equipment evaluation.

FITTS, PAUL M., University of Michigan, Ann Arbor, Mich.; Ph.D.; Professor, Psychology Dept., University of Michigan, Ann Arbor, Mich.; Trng.—Psychology; Int.—Engineering psychology, human performance theory.

FLANAGAN, JOHN C., 410 Amberson Ave., Pittsburgh 32, Pa.; Ph.D. 1934 (Mental Measurement); President & Director of Research, American Institute for Research, 410 Amberson Ave., Pittsburgh 32, Pa.; Trng.—Psychology, Statistics, Education; Int.—Developing techniques and evaluation procedures.

FLEXMAN, RALPH E., 1033 Christy Dr., Niceville, Fla.; M.A. 1950 (Psychology); Technical Director, Human Factors Office, Air Proving Ground Center, Eglin A.F.B., Fla.; Trng.—Aviation Psychology; Int.—System testing, training, and equipment design.

FLOOD, MERRILL M., University of Michigan, Ann Arbor, Mich.; Ph.D. 1935 (Mathematics); Professor of Industrial Engineering, Dept. of Industrial Engineering; Research Scientist, Mental Health Research Institute; University of Michigan, Ann Arbor, Mich.; Trng.—Mathematics; Int.—Mathematical theory of behavior and systems.

FOGEL, A., 3259 Geddes Dr., San Diego 17, Calif.

FOGEL, LAWRENCE J., 828 Deal Ct., San Diego 8, Calif.; M.S. 1952 (Electrical Engineering); Head, Reliability Group, Engineering Dept., Convair, San Diego Div., San Diego, Calif.; Trng.—Engineering; Int.—Display design, human decision making systems.

FOLLETTIE, J. F., U.S. Army Infantry Human Research Unit, Fort Benning, Ga.

FOLLEY, JOHN D., Forestwood Dr., R.D. #5, Box 197, Gibsonia, Pa.; M.S. 1953 (Psychology); Director, Human Factors Office, American Institute for Research, 410 Amberson Ave., Pittsburgh 32, Pa.; Trng.—Engineering, Experimental Psychology; Int.—System analysis, human factor technique development and quantification.

FORBES, THEODORE W., Box 606, E. Lansing, Mich.; Ph.D. 1931 (Applied & Experimental Psychology); Asst. Director in Charge of Research, Highway Traffic Safety Center, Michigan State University, E. Lansing, Mich.; Trng.—Psychology—Experimental, Applied, Statistical; Int.—Visibility, legibility, judgment and response, driving behavior.

FREEDMAN, TOBY, North American Aviation, Inc., Los Angeles Div. Int'l Airport, Los Angeles 45, Calif.

FRIED, CHARLES, 5026 No. Court Rd., Aberdeen, Md.; M.A. 1953 (Psychology); Research Psychologist, Human Engineering Laboratory, Aberdeen Proving Grounds, Md.; Trng.—Experimental Psychology; Int.—Visual displays and human engineering studies.

FUGAZZI, CARLO, 150-01 Reeves Ave., Flushing 67, N.Y.

GARDNER, ROBERT L., 235 E. McCormick Ave., State College, Pa.; M.S. 1955 (Psychology); Senior Psychologist, HRB-Singer, Inc., Science Park, State College, Pa.; Trng.—Psychology; Int.—Systems analysis, selection, training, equipment evaluation.

GARTNER, WALTER B., 20632 Blackhawk St., Chatsworth, Calif.; B.S. 1955 (Psychology); Research Associate, West Coast Facility, Psychological Research Associates, Inc., 15537 Ventura Blvd., Encinco, Calif.; Trng.—Military Aviation, Psychology; Int.—Information processing and decision making.

GAYLORD, RICHARD H., American Institute for Research, 6135 Kansas Ave., Washington 11, D.C.

GERSHON, ARTHUR, P. O. Box 126, Beverly Hills, Calif.

GIARRETTO, HENRY, 7107 LaSaine, Van Nuys, Calif.; Research Specialist, Lockheed Missiles & Space Division, Dept. 56-14, Automatic Data Processing Dept., Van Nuys, Calif.; Trng.—Engineering, Electronic; Int.—Missile weapon & space systems, operation & maintenance.

GIFFORD, ROBERT N., 2033 Euclid St., Apt. 10, Santa Monica, Calif.; B.S. 1951 (Electrical Engineering); Human Factors Specialist, Training Development Branch, System Development Corp., 2500 Colorado, Santa Monica, Calif.; Trng.—Electrical Engineering and Psychology; Int.—Man-machine relationships.

GLASER, ROBERT, 1617 Cathedral of Learning, University of Pittsburgh, Pa.

GLASSNER, HARVEY F., 3126½ Roberts St., Culver City, Calif.; A.B. 1950 (Physiology); Physiologist (Bioelectronics), Equipment and Safety Research Group, Douglas Aircraft Company, Inc., 827 Lapham Ave., El Segundo, Calif.; Trng.—Cardiovascular Physiology; Int.—Bioelectronics.

GLOVER, J. FRANK, 4407 Marble Hall Rd., Baltimore 18, Md.; Principal Industrial Designer, Bendix Radio Division, Bendix Aviation Corp., Baltimore, Md.; Trng.—Architecture; Int.—Tasks, environments, data application, appearance design.

GOLDBERG, MARVIN N., 1536 So. Wooster, Los Angeles, Calif.; M.A. 1958 (Physiology); Human Factors Research Engineer, Human Factors, North American Aviation, Inc., L. A. International Airport, Los Angeles, Calif.; Trng.—Zoology; Int.—Vision, thermal, biological instrumentation, toxicology.

GOLDEN, SANFORD S., 1001 Gayley Ave., Los Angeles 24, Calif.; D.D.S. 1942 (Dentistry); Dentist (self-employed); Int.—Time-motion studies related to dentistry.

GOLDMAN, ALEXANDER, 234 Jerusalem Ave., Levittown, N.Y.; Ph.D. 1959 (Psychology); Specialist Engineer, Design Safety and Reliability, Republic Aviation Corp., Farmingdale, L.I., N.Y.; Trng.—Psychology; Int.—Cockpit arrangements, maintenance.

GOLDSMITH, C. THOMAS, 31 Baldwin Ave., Massapequa, N.Y.; Ph.D. 1959 (Psychology); Human Factors Specialist, Grumman Aircraft Engineering Corp., Bethpage, N.Y.; Trng.—Psychology; Int.—Systems analysis; perceptual & motor skills.

GOODMAN, IRVING B., 4900 Calvert Rd., College Park, Md.; M.A. 1957 (Psychology); Human Factors Engineer, Maryland Division, Litton Industries, 4900 Calvert Rd., College Park, Md.; Trng.—Mechanical Engineering & Experimental Psychology; Int.—Information presentation, equipment maintenance, systems analysis.

GOODWIN, W. RICHARD, Box 302, Lodi, N.J.; Ph.D. 1955 (Experimental Psychology); Assistant Manager, System Development Corp., Lodi Divisions, Box 302, Lodi, N.J.

GORDON, DONALD A., Dept. Industrial Engineering, University of Michigan, Ann Arbor, Mich.

GORDON, JEROME J., 3551 Meier St., Los Angeles 66, Calif.

GRANT, GEORGE, 1218 So. Allen St., State College, Pa.; M.S. 1959 (Industrial Psychology); Senior Psychologist, Operations Dept., HRB-Singer, Inc., Science Park, State College, Pa.; Trng.—Experimental-Indus-

trial Psychology; Int.—Operations research, systems analysis, training displays.

GREEN, KENNETH E., 521 Wisteria Place, Santa Ana, Calif.

GRETHER, WALTER F., 425 Cherry Dr., Dayton, Ohio; Ph.D. 1938 (Psychology); Director of Operations, Aero Medical Laboratory, Wright Air Development Center, Wright-Patterson A.F.B., Ohio; Trng.—Psychology; Int.—Engineering psychology & aviation medicine.

GRINGS, WILLIAM W., 8020 Agnew Ave., Los Angeles 45, Calif.; Ph.D. 1946 (Psychology); Associate Professor of Psychology, University of Southern California, Los Angeles 7, Calif.; Trng.—Experimental and Theoretical Psychology; Int.—Behavior research methodology, human learning, perception.

GROTH, HILDE, 815 Hartzell St., Pacific Palisades, Calif.; Ph.D. 1957 (Psychology); Asst. Research Psychologist; U.C.L.A. Dept. of Engineering, Los Angeles, Calif.; Trng.—Experimental Psychology; Int.—Perceptual, motor skills.

GRUNDEMAN, FRED D., 100 Montreal, Playa Del Rey, Calif.

HALL, ALBERT C., 2650 Thrasher Lane, San Jose 25, Calif.; Ed.D. 1956 (Educational Psychology); Staff Psychologist (Human Engineering), Product Development Laboratory, Data Processing Division, International Business Machines Corp., Monterey & Cottle, San Jose, Calif.; Trng.—Physical Science, Education & Psychology; Int.—Simulation, problem solving & coded information displays.

HALTOM, PAUL T., 16601 So. Pacific Ave., Sunset Beach, Calif.; M.D. 1952 (Medicine); Consultant Aviation Medicine, Human Factors, Douglas Aircraft, Long Beach, Calif.; Trng.—Medicine; Int.—Aviation medicine.

HAMBURGER, CHARLES D., 11284 Montana Ave., Los Angeles, Calif.; M.A. 1958 (Psychology); Operations Research Analyst, System Training Production Dept., Product Development Group, System Development Corp., 2500 Colorado Blvd., Santa Monica, Calif.; Trng.—Psychology; Int.—Applied mathematics, model formation, system analysis.

HANES, LEWIS F., 804 Commercial Bldg., Dayton 2, Ohio.

HANIFAN, DONALD T., 751 So. Brand Blvd., San Fernando, Calif.; M.A. 1954 (Zoology); Head, Human Factors Group, Western Division, R & D Div. A, Collins Radio Co., 2700 W. Olive Ave., Burbank, Calif.; Trng.—Physiology, biophysics; Int.—Aircraft & electronic systems design, aviation physiology.

HARDESTY, GEORGE K. C., Box 156, Mayo, Md.

HARKEY, GABRIEL J., 4207 Pepper Drive, San Diego 5, Calif.

HARKINS, WILLIAM H., 66 W. Main St., Rockville, Conn.; B.A. 1954 (Industrial Design); Industrial Design Dept., Manager, Underwood Research & Engineering Lab., Underwood Corp., 56 Arbor St., Hartford, Conn.; Trng.—Industrial Design; Int.—Human behavior and motivation, general semantics.

HARSH, CHARLES M., 3110 Udall St., San Diego 6, Calif.

HARTMAN, BRYCE O., 746 Sumner Dr., San Antonio 9, Texas; Ph.D. 1952 (Psychology); Chief, Medical Psychology, Dept. of Neuropsychiatry, School of Aviation Medicine, U.S.A.F., Randolph A.F.B., Texas; Trng.—Human engineering; Int.—Motor skills, operational stress, systems problems.

HASBROOK, A. HOWARD, Box 466, Gilbert, Ariz.

HAZELL, JOSEPH W., 7201 Barnett Rd., Bethesda 14, Md., M.A. 1949 (Psychology); Human Factors Analyst, Booz, Allen Applied Research, Inc., 4921 Auburn Ave., Bethesda 14, Md.; Trng.—Physics, industrial & engineering psychology, operations analysis.

HEGLIN, HOWARD J., 20751 Kittridge St., Canoga Park, Calif.; Ph.D. 1955 (Experimental Psychology); Senior Research Engineer (Human Factors), Rocketdyne, North American Aviation, 6633 Canoga Ave., Canoga Park, Calif.; Trng.—Psychology, engineering; Int.—Engineering psychology, proficiency evaluation, criteria development.

HEINES, J. M. H., 460 Elm Ave., Westmount, Montreal, Canada.

HELVEY, T. C., 1030 Herman Ave., Orlando, Fla.; Director, Biophysics Branch, Radiation, Inc., 1030 Herman St., Orlando, Fla.

HEMBREE, HOWARD W., QM R & E Field Evaluation Agency, Fort Lee, Va.; Ph.D. 1952 (Psychology); Scientific Director (Research Psychologist), Quartermaster Research & Engineering Field Evaluation Agency, Fort Lee, Va.; Trng.—Applied experimental psychology; Int.—Equipment evaluation in man-machine-environment systems.

HERTZBERG, H. T. E., 414 N. Park Place, Yellow Springs, Ohio.

HICKEY, ALBERT E., 700 Commonwealth Ave., Boston, Mass.; Ph.D. 1954 (Experimental Psychology); Head—Human Data Processing Branch, Itek Corp., 700 Commonwealth Ave., Boston, Mass.; Trng.—Engineering & experimental psychology; Int.—Visual search & monitoring.

HIGHLAND, RICHARD W., 8536 McConnell Ave., Los Angeles 45, Calif.

HIRSCH, RICHARD S., International Business Machines Corp., Monterey & Cottle Rds., San Jose, Calif.; Ph.D. 1951 (Psychology); Research Psychologist, San Jose Research Lab., International Business Machines Corp., Monterey & Cottle Rds., San Jose, Calif.; Trng.—Experimental & educational psychology; Int.—Man-machine systems, perceptual-motor skills.

HOBAN, CHARLES F., Room 325, Towne Bldg., University of Pennsylvania, Philadelphia 4, Penna.

HOCKENBERRY, JACK K., 246 Milburn, Rochester 7, N.Y.; B.S. 1955 (Industrial Design); Appearance Design Engineer; A. & O. Division, Appearance Design Section, Dept. 81, Eastman Kodak Co., 400 Plymouth Ave., Rochester 4, N.Y.; Trng.—Industrial design; Int.—Human factors in product design.

HOFFMAN, LYLE S., 2064 Holmby Ave., Los Angeles 25, Calif.; M.A. 1952 (Psychology); Research Psychologist, Electronics Personnel Research Group, University of Southern California, University Park, Los Angeles 7, Calif.; Trng.—Industrial & personnel psychology.

HOLLABAUGH, J. F., Field Support Engineering, RCA Service Co., Inc., Camden 8, N.J.

HOLMES, ROBERT W., 2334 Turk Hill, Victor, N.Y.; B.S.M.E. 1940 (Mechanical Engineering); Staff Engineer, Electronic Engineering Dept., Stromberg Carlson Co., 1400 N. Goodman, Rochester, N.Y.; Trng.—Industrial engineering.

HOLSTEIN, DAVID, 10-03 Henderson Blvd., Fairlawn, N.J.; M.A. 1957 (Experimental Psychology); Psychologist, Systems Analysis, International Electric Corp., Paramus, N.J.; Trng.—Psychology; Int.—Systems analysis, decision processes, visual recognition.

HOPKINS, CHARLES O., 639 Camino De Encanto, Redondo Beach, Calif., Ph.D. 1952 (Psychology); Head, Research Group, Human Factors Engineering Section, Advanced Development Dept., Hughes Aircraft Co., Culver City, Calif.; Trng.—Engineering psychology; Int.—Control-display systems, physiological psychology, learning.

HOUGHTON, RICHARD A., JR., 206 Cold Spring Harbor, L.I., N.Y.; B.S.M.E. 1942 (Aeronautical Engineering); Prelim. Design. Proj. Engr., Systems Design Dept., Grumman Aircraft Engineering Corp., Bethpage, L.I., N.Y.; Int.—Sealed cabins, escape systems, space flight.

HOWLAND, DANIEL, Eng. Experimental Station, Ohio State University, Columbus, Ohio; Ph.D. 1955 (Research & Education); Associate Professor, Industrial Engineering, Director, Operations Research Group, The Ohio State University, Columbus 10, Ohio; Trng.—Engineering, psychology; Int.—Human factors, man-machine systems.

HOYT, RUTH, Defence Research Board, Dept. National Defence, Ottawa, Ontario, Canada; Ph.D. 1952 (Psychology); Senior Staff Officer, Human Resources Research Section, Dept. of National Defence, Defence Research Board, Room 4118, "A" Bldg., Cartier Sq., Ottawa, Ontario.

HOYT, WILLIAM G., 20302 Mobile St., Canoga Park, Calif.; M.A. 1953 (Psychology); Associate Human Factors Scientist, System Training Operations Dept., System Development Corp., Santa Monica, Calif.; Trng.—Psychology; Int.—Training, man-machine relationships, design, criterion development.

HUCHINGSON, R. DALE, Operational Factors Engineering Section, Chance-Vought Aircraft, Inc., Dallas, Texas; M.A. 1953 (Psychology); Human Factors Engineer, Operational Factors Engineering Section, Chance-Vought Aircraft, Inc., Dallas, Texas; Trng.—Applied experimental psychology; Int.—Safety analysis of display-control systems.

HUEBNER, DANIEL L., 154 Little Silver Pt. Rd., Little Silver, N.J.; M.A. 1955 (Psychology); Human Factors Coordinator, U.S. Army Signal Research & Develop. Lab., Engineering Sciences Dept., Human Factors Sec., Fort Monmouth, N.J.; Trng.—Psychology, experimental & clinical; Int.—Visual perception, human information processing.

HULBERT, SLADE F., 9720 Yoakum Dr., Beverly Hills, Calif.; Ph.D. 1957 (Psychology); Assistant Research Psychologist, Institute of Transportation & Traffic Engineering, University of California, Los Angeles 24, Calif.; Trng.—Psychology; Int.—Transportation systems research and education.

HUNTOON, RICHARD B., 206 Dorchester Ave., Apt. 3B, Syracuse 6, N.Y.; B.S. 1954 (Psychology); Human Factors Specialist, Heavy Military Electronics Equipment Dept., General Electric, Syracuse, N.Y.; Trng.—Applied psychology; Int.—Human factors considerations in electronic equipment.

HURT, G. REX, 6436 Forest Ave., Hammond, Indiana; Ph.D. 1958 (Psychology); Director of Psychological Services, Frank R. Valvoda & Associates, engineering, psychology; Int.—Vision, perception, training, behavior changes, testing.

HUSSMAN, THOMAS A., JR., Psychological Research Assoc., Inc., Encino, Calif.

IBISON, RICHARD A., 404 Butternut Dr., Vestal, N.Y.; Ph.D. 1951, (Educational Psychology); Human Factors Engineer, Light Military Equipment Dept., General Electric Co., Johnson City, N.Y.; Trng.—Psychology; Int.—Maintainability, training, simulators, armament controls & displays.

IRELAND, RICHARD J., 3210 No. 19th St., Arlington 1, Va.; B.S. 1952; Mechanical Design; Senior Designer, John I. Thompson & Co., Washington, D.C.; also Secretary of Inc, Incorporated, Arlington, Va.; Trng.—Mechanical & Industrial Design; Int.—Man-machine systems design.

ISHERWOOD, JOHN DAVID, 11822 Kearsarge St., Los Angeles 49, Calif.

JACOBS, HOWARD I., 5665 Rhodes Ave., North Hollywood, Calif.

JANSKY, CURTIS M., 120 E. 89th St., New York 28, N.Y.; B.S.E.E. 1949 (Communications); Product Program Coordinator, Product Planning Division, Royal McBee Corp., Westchester Ave., Port Chester, N.Y.; Trng.—Electrical Engineering; Int.—Optical displays & manual discreet controls.

JARRETT, HILTON F., 7803 Croydon Ave., Los Angeles 45, Calif.; Ph.D. 1957 (Psychology); Human Factors Scientist-Associate, System Development Corp., 2500 Colorado Ave., Santa Monica, Calif.

JENSEN, LENNARD V., 2405 169th Pl., Torrance, Calif.; A.B. 1950 (Psychology); Senior Research Engineer, Human Factors Group, North American Aviation, Inc., Los Angeles, Calif.; Trng.—Psychology; Int.—Aircraft crew-station design.

JENSEN, LEONARD L., 651 Fisher Rd., Grosse Pointe 30, Mich.; B.S. 1948 (Chemistry); Senior Research Engineer, Systems Research Section, Automotive Research Dept., Ford Motor Co., Engineering Staff, P. O. Box 2053, Dearborn, Mich.; Trng.—Biochemistry & Physiology;; Int.—Physiological factors in automotive design.

JOHNSON, CHARLES W., 1351 Vulcan, El Cajon, Calif.; M.A. 1952 (Experimental Psychology); Technical Specialist in charge of Human Factors, Stromberg-Carlson-San Diego, 1895 Hancock St., San Diego 12, Calif.; Trng.—Human Factors; Int.—Experimental engineering psychology, display & control systems.

JOHNSON, GEORGE H., 7711 Kentwood Ave., Los Angeles 45, Calif.; Ph.D. 1951 (Psychology); Assistant Head, Training Operations Department, System Development Corp., 2500 Colorado Ave., Santa Monica, Calif.; Trng.—Psychology; Int.—System analysis and evaluation, system training.

JONES, L. N., 11822 Peacock Court, Garden Grove, Calif.

KACH, PETER H., 823 Lincoln Blvd., Santa Monica, Calif.; M.A. 1954 (Psychology); Research Engineer, Human Factors & Bioastronautics, Missiles & Space Systems, Douglas Aircraft Co., 3000 Ocean Park Blvd., Santa Monica, Calif.; Trng.—Psychology; Int.—Tools & techniques.

KAHN, ARTHUR, 2 Cove of Cork Lane, Annapolis, Md.; Ph.D. 1952 (Psychology); Fellow Engineer, Air Arm Division, Westinghouse Electric Corp., P. O. Box 746, Baltimore 3, Md.; Trng.—Experimental Psychology; Int.—Tracking, information processing, detection, task analysis.

KAPNER, WILLIAM S., 214 E. 32nd Pl., Tuscaloosa, Ala.; M.B.A. 1956 (Business Administration); Professional Engineer, Equipment & Information Handling, Gulf States Paper Corp., Tuscaloosa, Ala.; Trng.—Administrative Behavior; Int.—Human as a component in system.

KARLIN, JOHN E., Bell Telephone Labs., Murray Hill, N.J.; Ph.D. 1942 (Psychology); Head, Human Factors Engineering, Bell Telephone Labs., Murray Hill, N.J.; Trng.—Psychology & Engineering; Int.—Man-machine relationships.

KARROLL, JOSEPH E., 176 Red Rose Dr., Levittown, Pa.; M.A. 1951 (Experimental Psychology); Engineer, Astro Electronic Products Div., Radio Corporation of America; P. O. Box 800, Princeton, N.J.; Trng.—Mathematics, Psychology, Engineering; Int.—Systems design, integration, and human engineering.

KENYON, WILFRED, 458 21st St., Santa Monica, Calif.; Design Engineer, Preliminary Design Division, Lockheed Aircraft Corp., Burbank Calif.; Int.—Escape systems, crew compartment.

KERBER, HAROLD E., 289 Bentleyville Rd., Chagrin Falls, Ohio; Ph.D. 1958 (Psychology); Head, Human Factors Engineering, Biomechanical R & D Section, Goodyear Aircraft Corp., Akron 15, Ohio; Trng.—Mechanical Engineering & Psychology; Int.—Man/machine design, research, systems, safety.

KIDD, JERRY S., 422 E. Clearview, Worthington, Ohio; Ph.D. 1956 (Psychology); Research Associate, Laboratory of Aviation Psychology, Ohio State University, 1314 Kinnear Rd., Columbus 8, Ohio; Trng.—Experimental-Social Psychology; Int.—Complex man-machine systems.

KING, BARRY G., 8605 Cameron St., Silver Spring, Md., Ph.D. 1934 (Physiology); Vice President, Life Sciences, Operations Research, Inc., 8605 Cameron St., Silver Spring, Md., Trng.—Physiology; Int.—Stress physiology, environmental physiology.

KING, WILLIAM J., Human Factors Section, Electric Boat Co., Groton, Conn.

KINZER, JOHN R., 829 11th St., Santa Monica, Calif.; Ph.D. 1940 (Psychology); Human Factors Scientist, Senior, System Development Corp., 2500 Colorado Ave., Santa Monica, Calif.; Trng.—Educational Psychology, Philosophy; Int.—Training.

KNACKE, THEODORE W., 137 Oregon St., El Segundo, Calif.; Chief Engineer, Aeronautical Equipment Research Corp., A Division of M. Steinthal & Co., Inc., 137 Oregeon St., El Segundo, Calif.; Trng.—Aeronautical Engineering.

KNIGHT, RICHARD W., 6708 Whitsett Ave., Apt. 2, North Hollywood, Calif.

KONECCI, EUGENE B., 1902 Arizona, Santa Monica, Calif.; Ph.D. 1950 (Medical Physiology); Head, Supervisor, Life Sciences, Missiles and Space Systems, A260, Douglas Aircraft Co., Inc., 3000 Ocean Park Blvd., Santa Monica, Calif.; Trng.—Medical & Aviation Physiology & Radiobiology; Int.—All facets of missile and space systems.

KORNFIELD, ALFRED T., 81 So. Ellicott St., Williamsville, Buffalo 21, N.Y.

KRAFT, JACK A., 839 Cardova Dr., N.E., Atlanta 5, Ga.; Ed.D. 1950 (Psychology); Ed.D. 1950 (Psychology); Manager, Human Factors Research Dept., Lockheed Aircraft, Georgia Division, Marietta, Ga.; Trng.—Psychology; Int.—Flight station design & basic experimental research.

KRYTER, KARL D., 154 Hampshire Rd., Wellesley Hills, Mass.

KUBY, MILTON, 237 Oakwood Rd., Huntington Station, N.Y.; M.A. 1949 (Psychology); Human Engineering Specialist, Research and Development, Republic Aviation Corp., Farmingdale, N.Y.; Trng.—Engineering and Psychology; Int.—Manned space vehicle & aircraft development.

KULP, CHARLES M., Rowland & Co., P. O. Box #61, Haddonfield, N.J.; A.B. 1959 (Psychology); Assistant Scientist, Human Factors Engineering, Rowland & Co., P. O. Box #61, Haddonfield, N.J.; Trng.—Experimental Psychology; Int.—Psychophysiology, vision, applied anthropometrics, bibliographic research.

KURKE, MARTIN I., Dunlap & Associates, Inc., 425 13th St., N.W., Washington 4, D.C.; M.A. 1953 (Psychology); Human Factors Scientist, Dunlap & Associates, Inc., 425 13th St., N.W., Washington 4, D.C.; Trng.—Psychology; Int.—Systems analysis, development, evaluation, operations research.

KYROPOULOS, PETER, General Motors Technical Center, Warren, Mich.; Ph.D. 1948 (Mechanical Engineering); Technical Director, Styling Staff, General Motors Corp., Detroit, Mich.; Trng.—Physics, Mechanical Engineering; Int.—Man-automobile-environment relationship.

LA PORTE, HAROLD R., JR., 6521 W. 84 Pl., Los Angeles, Calif., M.A. 1951 (Experimental Psychology); Senior Research Engineer, Human Factors Group, Advanced Engineering, Autonetics-A Division of North American Aircraft, 9150 E. Imperial Hwy., Downey, Calif.; Trng.—Experimental Psychology; Int.—Systems analysis, control/display design, maintenance.

LATHAM, ALBERT J., 4440 Beverly Dr., Dallas 5, Texas; Ph.D. 1948 (Psychology); Engineering Specialist, Human Factors, Engineering Dept., Chance Vought Aircraft, Inc., Dallas, Texas; Trng.—Psychology; Int.—Engineering psychology.

LATHROP, P. A., 19 Sweetgum Rd., Levittown, Pa.

LAW, HOWARD C., 1920½ Federal Ave., Los Angeles 25, Calif.

LAYMON, RICHARD S., 11618 Kiowa Ave., Los Angeles 49, Calif.; Ph.D. 1956 (Psychology); Human Factor Scientist, System Development Corp., 2500 Colorado Ave., Santa Monica, Calif.; Trng.—Experimental Psychology; Int.—Human engineering, perception, systems engineering.

LEADINGHAM, ROBERT L., 5024 Manduria St., Orlando, Fla.

LEARNER, DAVID B., Research Labs, General Motors Corp., Warren, Mich.; Ph.D. 1956 (Experimental Psychology); Head, Human Factors Research Group, Research Labs, General Motors Corp., Warren, Mich.; Trng.—Psychology; Int.—Systems research control systems, product analysis.

LEDERER, JEROME F., Flight Safety Foundation, Inc., 468 Fourth Ave., New York 16, N.Y.

LEE, FRANCIS J., 4 Washington Ave., Cambridge, Mass.; Ph.D. 1955 (Social Psychology & Personality); Manager, Training Services, Raytheon Co., 1336 Soldiers Field Rd., Brighton, Mass.; Trng.—Psychology; Int.—Systems engineering, display & control equipment.

LEFRITZ, NORMAN M., 26421 Basswood Ave., Rolling Hills, Calif.

LEVEDAHL, BLAINE H., Dept. of Zoology, University of California, Los Angeles 24, Calif.; Ph.D. 1949 (Biochemistry); Associate Professor Zoology, Dept. of Zoology, University of California, Los Angeles 24, Calif.; Trng.—Biophysics; Int.—Physiology & biophysics.

LEWIS, R. E. F., Psychology & Sociology Wing, D.R.M.L., P. O. Box 62, Postal Station "K," Toronto, Ontario, Canada.

LEWIS, WILLIAM L., 2046 Chilton Dr., Glendale 1, Calif.; Western Manager, Flight Safety Foundation, Inc., 2038-½ Griffith Park Blvd., Los Angeles 39, Calif.; Trng.—Aeronautical Engineering; Int.—Aircraft accident prevention through improved design.

LICKLIDER, J. C. R., Bolt Beranek & Newman, Inc., 50 Moulton St., Cambridge 38, Mass.

LINDSEY, JEFFERSON FRANKLIN, 72 Laurie Dr., Ft. Walton Beach, Fla.; M.A. 1950 (Research); Chief, SAC/Cargo Branch, Human Factors Office (PGTF), Air Proving Ground Center, Eglin A.F.B., Fla.; Trng.—Mathematics, Education; Int.—Evaluating man-machine-environmental relationships.

LINSKEY, JOSEPH W., 259 DeSoto Pl., Fairview, N.J.; M.A. 1955 (Psychology); Associate Research Scientist, Research Div., College of Engineering, New York University, New York 3, N.Y.; Int.—Psychological stress, safety, man in space.

LIPPERT, STANLEY, 9044 Wonderland Ave., Los Angeles 46, Calif.; B.A. 1935 (Physics); Coordinator, Human Factors Group, Engineering Dept. A-250 Santa Monica Div., Douglas Aircraft Co., Inc., 3000 Ocean Park Blvd., Santa Monica, Calif.; Trng.—Physics, Education; Int.—Acoustics, seating, anthropometry, air transport, human factors philosophy.

LITT, BERTRAM D., 241 Central Park West, New York, N.Y.; M.A. 1952 (Physiology-Ecology); Associate Research Scientist, Prosthetics Devices Study, New York University, College of Engineering, Research Division, 252 Seventh Ave., New York 1, N.Y.; Trng.—Physiology; Int.—Social-psychology, bio-mechanics, physiology.

LITTLE, HENRY, 20 Acorn Park, Cambridge 40, Mass., M.B.A. 1948 (Manufacturing); Engineering Division, Arthur D. Little, Inc., 20 Acorn Park, Cambridge 40, Mass.; Trng.—Mechanical Engineering; Int.—Simplified engineering design for human operators.

LOMBARD, C. F., 27650 Saddle Rd., Rolling Hills, Calif.

LORENZ, E. THEODORE, 2324 Sixth St., Moline, Ill.; B.S. 1950 (Industrial Design); Manager, Industrial Design Div., Mast Development Co., Inc., 2212 E. 12th St., Davenport, Iowa; Trng.—Industrial Design; Int.—Personal comfort facilities—airplane crew stations.

LUND, MAX W., Engineering Psychology Branch, Office of Naval Research, Washington 25, D.C.; Ph.D. 1940 (Psychology); Head Engineering Psychology Branch, Office of Naval Research, Washington, D.C.; Trng.—Psychology.

LYMAN, ARTHUR L., 104-25 191st St., Hollis 12, N.Y.; B.S. 1951 (Physics); Human Factors Engineer, Titan Project Section, American Machine & Foundry, 11 Bruce Pl., Greenwich, Conn.; Trng.—Human Factors, Engineering Research; Int.—Space & missile technology, human locomotion.

LYMAN, JOHN, Dept. of Engineering, University of California, Los Angeles 24, Calif.; Ph.D. 1951 (Psychology); Associate Professor of Engineering & Associate Professor of Psychology, Dept. of Engineering, University of California, Los Angeles 24, Calif.; Trng.—Psychology & Mathematics; Int.—General human factors research & education.

MAC CASLIN, EUGENE F., 1658 Martin Ave., Sunnyvale, Calif.; Ph.D. (Psychology); Engineering Psychologist, Palo Alto Laboratory, Link Aviation, Inc., Box 1318, Palo Alto, Calif.; Trng.—Experimental Psychology, Learning; Int.—System development, task analysis, human engineering.

MACKIE, R. R., 5375 Stillwater Dr., Los Angeles 56, Calif.

MACKWORTH, NORMAN H., 61 Gwendolen Ave., Willowdale, Toronto, Canada; Ph.D. 1947 (Experimental Psychology); Investigator, Defence Research Board of Canada, Defence Research Medical Laboratories, Postal Station K, P. O. Box 62, Toronto 12, Canada; Trng.—Experimental Psychology; Int.—Vigilance & psychophysiology of adverse conditions.

MANGELSDORF, JOHN E., 1591 Mary Ave., Sunnyvale, Calif.; Ph.D. 1955 (Experimental Psychology); Supervisor, Human Engineering Staff, Missiles & Space Division, Lockheed Aircraft Corp., Sunnyvale, Calif.; Trng.—Engineering Psychology; Int.—Human factors in design & operation of missile/space systems.

MARANO, JOSEPH A., 664 Manchester Terrace, Inglewood, Calif.; O.D. 1951 (Optometry); Consultant, Education Dept., Wesley Jessen Contact Lens Co. of America, 711 So. Vermont Ave., Los Angeles 5, Calif.; Int.—Vision.

MARSHALL, T. A., JR., 569 Westfield Ave., Westfield, N.J.

MARTIN, DELOSS K., 1320 Fort Myer Dr., Arlington 9, Va.; B.S. 1920 (Electrical Engineering); Consulting Engineer (Self-employed), 1320 Fort Myer Dr., Arlington 9, Va.; Trng.—Communication and Air Traffic Control; Int.—Displays of information.

MARZOCCO, FRANK N., 1047 Las Pulgas Rd., Pacific Palisades, Calif.

MASON, RAIGH, Box 99, Littleton Common, Mass.; M.Ed. 1940 (Educational Psychology); Research Psychologist, U.S. Air Force, Operational Applications Laboratory, Air Force Cambridge Research Center, Mass.; Trng.—Education, Industrial Psychology; Int.—Man-machine compatibility, human stress research.

MATHENY, WILLIAM G., 7109 Richland Road, Fort Worth, Tex.; Ph.D. 1949 (Industrial Psychology); Chief, Human Factors, Bell Helicopter Corp., Box 482, Fort Worth, Texas; Trng.—Industrial Psychology; Int.—Information display, system dynamics.

MATHEWSON, JOHN H., Institute of Transportation and Traffic Engineering, University of California, Los Angeles, Calif.; M.S. 1938 (Engineering); Professor of Engineering; Assistant Director, Institute of Transportation and Traffic Engineering, University of California, 405 Hilgard Ave., Los Angeles 24, Calif.; Trng.—Industrial Engineering; Int.—Human factors in engineering systems.

MAUCH, HANS A., Mauch Research & Dev. Lab., 4418 Airway Rd., Dayton 31, Ohio.

MAXWELL, IAN R., 4 Fitzroy Square, London W.I., England.

MAYRAND, FRED R., 74-10 35th Ave., Jackson Heights 72, N.Y.; Ph.D. 1958 (Psychology); Human Factors Dept., System Development Corp., P. O. Box 302, Lodi, N.J.; Trng.—Psychology, Educational Psychology; Int.—General systems theeory, man-machine systems.

MAYZNER, MARK S., 15 Sydney Ave., Deal, N.J.; Ph.D. 1955 (Experimental Psychology); Member of Technical Staff, Military Systems Studies, Bell Telephone Laboratories, Whippany, N.J.; Trng.—Experimental Psychology; Int.—Decision-making systems analysis and evaluation.

MCCLERNAN, L. M., 3429 Ravena St., Royal Oak, Mich.

MC CORMICK, FRNEST J., Occupational Research Center, Purdue University, Lafayette, Ind.; Ph.D. 1948 (Industrial Psychology); Professor of Psychology, Occupational Research Center, Purdue University, Lafayette, Ind.; Trng.—Industrial Psychology; Int.—Research.

MC CORMICK, WILLIAM G., 1935 Cloverfield, Apt. 4, Santa Monica, Calif.; M.A. 1957 (Physiology); Research Analyst, Santa Monica Division A-250, Douglas Aircraft Co., 3000 Ocean Park Blvd., Santa Monica, Calif.; Trng.—Physiology, Psychology, Mathematics; Int.—Physiological considerations of aircraft design.

MCCORNACK, ROBERT L., System Development Corporation, 2500 Colorado Ave., Santa Monica, Calif.

MC CUTCHAN, JOSEPH W., 16642 Moorpark, Encino, Calif.; M.S. 1950 (Engineering); Associate Professor, University of California, Dept. of Engineering, Los Angeles 24, Calif.; Trng.—Mechanical Engineering; Int.—Human tolerance to heat.

MCDONALD, J. F., 10867 Willowcrest Pl., North Hollywood, Calif.

MC FADDEN, FRNEST B., 5012 N.W. 47th, Oklahoma City, Okla.; M.S. 1957 (Physiology); Research Associate in Physiology, Civil Aviation Medical Research Laboratory, Federal Aviation Agency, Office of Civil Air Surgeon, Aeronautical Center, Box 1082, Oklahoma City, Okla.; Trng.—Respiratory & Aviation Physiology; Int.—Aviation physiology, respiration, acceleration, decompression, biomechanics.

MC FARLAND, ROSS A., 1 Shattuck St., Boston 15, Mass.; Ph.D. 1928 (Teaching & Research); Professor of Environmental Hygiene, Director Guggenheim Center for Aviation Health & Safety, Harvard School of Public Health, 1 Shattuck St., Boston 15, Mass.; Trng.—Physiological Psychology; Int.—Human engineering & aviation health & safety.

MC GOVERN, THOMAS F., 5314 42nd Ave., Hyattsville, Md.; LL.B. 1939 (Law); Admiralty-Attorney, Trial, Civil Division, Dept. of Justice, Washington 25, D.C.; Trng.—Law, Admiralty, Collisions; Int.—Radar assisted collisions.

MCTEE, A. C., Route 8, Box 778, Fort Worth, Texas.

MEAD, LEONARD C., Tufts University, Medford 55, Mass.; Ph.D. 1939 (Psychology); Vice President and Provost, Tufts University, Medford 55, Mass.; Trng.—Experimental and Applied Psychology; Int.—Vision, visual displays, training, fatigue.

MEEHAN, JOHN P., 460 Walnut Ave., Arcadia, Calif.; M.D. 1948 (Medicine); Associate Professor of Physiology, School of Medicine, University of Southern California, Los Angeles 7, Calif.; Trng.—Physiology, Medicine; Inst.—Acceleration, altitude, human performance.

MEIGS, PURDY F., 1101 Princeton Dr., S.E., Albuquerque, N.M.; B.S. 1927 (Electrical Engineering); Staff Member (Human Engineer), Systems Evaluation Section, Sandia Corp., Sandia Base, Albuquerque, N.M.; Int.—Layout of controls and displays.

MELTON, ARTHUR W., Dept. of Psychology, University of Michigan, Ann Arbor, Mich.; Ph.D. 1932 (Psychology); Professor of Psychology; Head, Engineering Psychology Group, Department of Psychology, University of Michigan, Ann Arbor, Mich.; Trng.—Psychology; Int.—Training, training devices, information processing.

MENEAR, WALTER R., 785 Fruithurst Drive, Mt. Lebanon, Pittsburgh 34, Pa.; B.S. 1937 (Electrical Engineering); Plant Project Engineer, The Bell Telephone Co. of Pa., Plant Engineering Dept., 421 Broad St., Sewickley, Pa.; Trng.—Communications, Electronics; Int.—Plant design and construction.

MERKIN, ALLAN, 911 N. Belgrade Rd., Silver Spring, Md.; B.S. 1934 (Chemistry and Pharmacy); Research & Development (General) Engineer, Bureau of Aeronautics, Dept. of the Navy, Washington 25, D.C.; Trng.—Aeronautical Research (Crash protection, acoustics & optics); Int.—Aeronautical safety, protective and survival equipment.

MICHELI, GENE S., 34-24 82 St., Jackson Heights 72, N.Y.; M.A. 1952 (Psychology); Psychologist (Experimental & Physiological), Human Engineering Dept., U.S. Naval Training Device Center, Port Washington, L.I., N.Y.; Trng.—Psychology; Int.—Training devices for complex systems.

MILBOUER, JOHN A., 255-05 75th Ave., Glen Oaks, N.Y.; B.S. 1941 (Electrical Engineering); Engineering Sales Manager, Consolidated Airborne Systems, Inc., 72 E. 2nd St., Mineola, N.Y.; Trng.—Electrical Engineering, preceded by Pre-Med; Int.—Comparative systems and physiological transducers.

MILLER, CHARLES O., 920 Tarryall Dr., Dallas 24, Texas.

MILLER, ROBERT B., Colonial House, South Road, Poughkeepsie, N.Y.; Ph.D. 1947 (Psychology); Research Psychologist, Product Development Laboratory, Data Systems Division, IBM Corp., Poughkeepsie, N.Y.; Trng.—Experimental Psychology; Int.—Advanced system design, personnel subsystems.

MINNEY, ORVAL H., 9824 Hampshire St., Cucamonga, Calif.

MITCHELL, MEREDITH B., 5927 Willoughby, Los Angeles 38, Calif.

MOREHOUSE, LAURENCE E., 10926 Verano Rd., Los Angeles 24, Calif.

MORGAN, CONRAD J., 7 Tanglewood Circle, Reading, Mass.; Senior Analyst, Operational Engineering Section, AVCO Research and Advanced Development Laboratory, 201 Lowell St., Wilmington, Mass.; Int.—Ground support equipment, missiles.

MORGAN, LAVERNE E.; P. O. Box 34, La Canada, Calif.; B.S. 1939 (Mechanical Engineering); Engineering Manager, Engineering Department, Pacific Scientific Aeroproducts, 10242 Placentia Ave., Anaheim, Calif.; Int.—Aircraft escape systems and safety components for aircraft.

MOWER, RALPH D., 574 31st St., Manhattan Beach, Calif.

MUCKLER, FREDERICK A., 130 W. Limestone St., Yellow Springs, Ohio.

MURPHY, EDWARD A., JR., 907 Highview Ave., Manhattan Beach, Calif.; B.S. 1940 (Military Science); Senior Engineer, Escape System Testing, Human Factors Group, Weapon Systems Production Design, North American Aviation, Inc., Los Angeles International Airport, Calif.; Trng.—Military Engineering, Military Pilot, Flight Safety Engineering, Aeronautical Engineering USAFIT; Int.—Escape systems, pressure suits, instrument presentation.

MURPHY, EUGENE F., 252 Seventh Ave., New York 1, N.Y.

MURRAY, RICHARD T., M.D. 25 Lattintown Road, Newburgh, N.Y.; A.B. 1957 (Industrial Psychology); Human Factors Specialist, SAGE System Training Branch-Field Group, System Development Corp., 2500 Colorado Ave., Santa Monica, Calif.; Trng.—Human Factors; Int.—Human actions working with electronic computers.

NADEL, AARON B., 735 State St., Santa Barbara, Calif.; Ph.D. 1938 (Psychology); Psychologist, Technical Military Planning Operation, Def. System Dept., General Electric Co., 735 State St., Santa Barbara, Calif.; Trng.—Psychology: Experimental, Physiological, Clinical, Abnormal; Int.—Space, anti-missiles, long-range planning, human engineering.

NARVA, MARSHALL A., 917 Cherry Dr., Dayton, Ohio; M.S. 1955 (Psychology); Human Factors Associate, The Martin Co., Baltimore, Md.; Trng. Psychology; Int.—Display-control characteristics.

NESTOR, GEORGE, 266 Frances St., Teaneck, N.J.; B.A.; Manager, Display Equipment Laboratory, Avion Div., A.C.F. Industries; Trng.—Mathematics; Int.—Man-machine interaction.

NEUMANN, HAROLD L., 432 Via Los Miradores, Redondo Beach, Calif.

NEWMAN, PAUL H., 3205 Foothill Rd., Santa Barbara, Calif.

NICHOLS, DARYL G., 6517 Will Rogers, Los Angeles 45, Calif.

NICKLAS, DOUGLAS R., 670 Greyhound Rd., Baltimore 21, Md.; M.A. 1951 (Experimental Psychology); Human Factors Specialist, Missiles & Electronic Division, GSE Dept., The Martin Co., Middle River, Baltimore, Md.; Trng.—Experimental Psychology; Int.—Human Engineering applications & applied research.

NORDSTROM, K. LENNART, Swedish Aircraft Co., SAAB, Systems Engineering Dept., Linkoping, Sweden.

OBERMAYER, RICHARD W., 139 Dayton St., Yellow Springs, Ohio.

OBERT-THORN, WILLIAM C., 10 Kirkwood Rd., Port Washington, N.Y.; M.A. 1956 (Psychology); Research Psychologist (Experimental & Physiological), Human Engineering Dept., U.S. Naval Training Device Center, Port Washington, N.Y.; Trng.—Experimental Psychology; Int.—Visual problems.

O'CONNELL, EUGENE R., 5343 Blackwelder, Los Angeles 16, Calif.; M.S. 1956 (Physical Education); Research Assistant, Physical Education, University of California, Los Angeles 24, Calif.; Trng.—Scientific Basis of Physical Education; Int.—Research-human performance, Physiological stress measurement.

OEHRLEIN, THOMAS F., 8446 Poppy Way, Buena Park, Calif.

OETTINGER, L., JR., 2265 E. Foothill Blvd., Pasadena, Calif.

OKANES, MARVIN M., 8420 Regis Way, Los Angeles, Calif.; Ph.D. 1956 (Psychology); Human Factors Scientist, System Training Operations Dept., System Development Corp., Santa Monica, Calif.; Trng.—Psychology; Int.—Man-machine system design & training.

OLDER, HARRY, 507 So. 18th St., Arlington 2, Va.; Ph.D. 1942 (Psychology); President, Psychological Research Associates, Inc., 507 So. 18th St., Arlington 2, Va.; Trng.—Psychologist.

OLSON, BERNARD A., 6738 E. Independence Pl., Tulsa, Okla.; B.S. 1949 (Aeronautical Engineering); Design Engineer, Interiors Design Group, Douglas Aircraft Co., Inc., 2000 No. Memorial Dr., Tulsa, Okla.; Trng.—Engineering; Int.—Safety, escape systems.

ORLANSKY, JESSE, 429 Atlantic St., Stamford, Conn.; Ph.D. 1940 (Psychology); Vice-president, Dunlap & Associates, Inc., 429 Atlantic St., Stamford, Conn.; Trng.—Psychology; Int.—Systems analysis & design perception.

ORNSTEIN, GEORGE N., 1544 Simpson Dr., Columbus, Ohio; M.A. 1952 (Psychology); Engineering Specialist—Research, Military Operations Analysis, North American Aviation, Inc., 4300 E. 5th Ave., Columbus, Ohio; Trng.—Psychology; Int.—Systems, statistics, models, psychomotor performance, vision.

OUTCALT, N. R., 703 Rosewood Lane, Arlington, Texas; M.A. 1952 (Experimental Psychology); Lead Weapons System Engineer, Systems Analysis Section, Chance Vought Aircraft, Dallas, Texas; Trng.—Engineering, Experimental & Aviation Psychology; Int.—Visual communication, human operator task analysis.

OZKAPTAN, HALIM, 142-22 32nd Ave., Flushing 54, N.Y.; M.A. 1953 (Psychology); Research & Development Engineer, Space Environment Laboratory, Research & Development Center, Republic Aviation, Farmingdale, L.I., N.Y.; Trng.—Research Psychology; Int.—Human factor research in spacecraft, missiles and advanced aircraft.

PARKER, JAMES W., 11800 Shaker Blvd., Cleveland 20, Ohio; M.S. 1952 (Industrial Psychology); Research

Associate, Personnel Research & Development Corp., 11800 Shaker Blvd., Cleveland 20, Ohio; Trng.—Industrial Psychology, Experimental Statistics, Human Engineering; Int.—Personnel & training requirements, human engineering.

PARKER, ROBERT N., 11430½ National Blvd., Los Angeles, Calif.; M.S. 1956 (Engineering); Associate in Engineering, University of California, Los Angeles 24, Calif.; Trng.—Engineering; Int.—Systems engineering.

PARSONS, HENRY M., 3750 Crownridge Dr., Sherman Oaks, Calif.; M.A. 1947 (Psychology); Human Factors Scientist, System Development Corp., Training Development Branch, 2400 Colorado, Santa Monica, Calif.; Trng.—Psychology; Int.—System analysis & training, equipment design.

PASKUSZ, GERHARD F., Dept. of Engineering, University of Calif., Los Angeles, Calif.

PAYNE, THOMAS A., Douglas Aircraft, Long Beach, Calif.; Ph.D. 1952 (Psychology); Research Psychologist, Douglas Aircraft, Long Beach, Calif.; Trng.—Experimental Psychology; Int.—Flight & navigation displays.

PECORARO, JOSEPH N., 10 Strawberry Lane, Huntington, L.I., N.Y.; M.S. 1939 (Aero-Mechanical Engineering); Head Equipment Research Div., U.S.N. T.D.C.O.N.R., Port Washington, N.Y.; Trng.—Engineering; Int.—Aircraft instrumentation, research, tools (aero-medical), space equipment & trainers.

PEIZER, EDWARD, 2347 Devon Street, East Meadow, Long Island, N.Y.

PENN, ROBERT, 9463 Seltzer Ct., San Diego 11, Calif.; Ph.D.; Senior Research Engineer, Convair-San Diego, A Division of General Dynamics, San Diego, Calif.; Trng.—Experimental & Industrial Psychology; Int.—Flight safety, selection & training performance measurement.

PERNINI, HENRY M., 1670 Farwell Ave., Chicago 26, Ill.; Senior Design Engineer, Division of Mechanical Engineering Research, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.; Trng.—Mechanical Engineering; Int.—Anthropometry, biomechanics, physiology, high altitude equipment.

PETERS, GEORGE A., 943 Fourth St., Santa Monica, Calif.; M.A. 1954 (Psychology); Research Engineer, Engineering Dept., Douglas Aircraft Co., Inc., El Segundo, Calif.; Trng.—Psychology; Int.—Systems Analysis, equipment design, operations research.

PETTY, G. R., JR., 9410 Woodland Drive., Silver Spring, Md.

PLANT, MISS JANE, 706 Park Ave., Baltimore 1, Md.; Fellow of Royal Geographical Society, Technical Writer, Human Factors Group, Bendix Radio Division, Towson 4, Md.; Trng.—Commercial Pilot & Instructor, Human Engineering; Int.—Displays, keyboards, human factors research, communication.

POPPEN, JOHN R., 10126 Whitaker Ave., Granada Hills, Calif.; M.D. 1917 (Medicine); Consultation, Scientific Research (Self employed); Trng.—Medicine; Int.—Flight surgeon.

PORTER, EUGENE M., 4940 Betsy Dr., Columbus 13, Ohio; B.S. 1954 (Architecture); Electronic Warfare Officer, U.S.A.F., Lockbourne A.F.B., Ohio; Trng.—Electronics & architectural design; Int.—Airborne weapons systems.

PRICE, HAROLD E., 15537 Ventura Blvd., Encino, Calif.

QUEAL, RALPH W., JR., 7844 S.E. 72nd, Mercer Island, Wash.; Ph.D. 1955 (Psychology); Aero-Space Division, Mail Stop 09-33, Boeing Airplane Co., Seattle 24, Wash.; Int.—Systems research and analysis.

RABIDEAU, GERALD F., 7113 Penfield Ave., Canoga Park, Calif.; Ph.D. 1953 (Industrial Psychology); Engineering Specialist—Human Engineering, Dept. 3545, Norair Division, Northrop Corp., 1001 E. Broadway, Hawthorne, Calif.; Trng.—Applied Experimental Psychology; Int.—Psychophysics, information processing, task analysis, training.

RADKE, ARTHUR O., 4422 N. Glenway, Wauwatosia 18, Wis.

RAPPAPORT, M., 309-2 Stanford Village, Stanford, Calif.

REHMAN, IRVING, 5153 Tampa Ave., Tarzana, Calif.; Ph.D. 1940 (Anatomy); Associate Professor Anatomy, Physiological Anatomy, University Southern California, School of Medicine, Dept. of Anatomy, University Park, Los Angeles 7, Calif.; Trng.—Human Applied Anatomy; Int.—Applied and functional anatomy and physiology.

RHOADES, MARION V., Psycho-Pharmacology Service Center, National Institute of Mental Health, National Institute of Health, Bethesda, Md.

RICHLAND, MALCOLM, 222 Via Anita, Redondo Beach, Calif.; M.A. 1954 (Education); Behavioral Scientist (Human Factors), System Development Corp., 2400 Colorado, Santa Monica, Calif.; Trng.—Education; Int.—System training in a man-machine environment.

RICKARD, HAROLD J., Qtrs. D., U.S. Naval Air Station, Seattle 15, Washington; M.D. 1935 (Medicine and surgery); Sr. Medical Officer & Flight Surgeon, U.S. Navy, Aviation Medical Div., Washington, D.C.; Trng.—Medicine, surgery, flight surgery; Int.—Pilot-aircraft applicability, adaptability and compatability.

RIESZ, ROBERT R., 256 Washington Ave., Chatham, N.J.; M.A. 1926 (Physics); Member of Technical Staff, Bell Telephone Laboratories, Murray Hill, N.J.; Trng.—Engineering physics; Int.—Engineering of communication systems, psychophysics, human factors.

RITCHIE, MALCOLM L., 432 Danforth Place, Dayton 31, Ohio; Ph.D. 1953 (Psychology); President, Ritchie & Assoc., Inc., 44 So. Ludlow, Dayton 2, Ohio; Trng.—Experimental psychology; Int.—The operation of complex equipment.

RITTERRATH, F. ARTHUR, 2120 Seville Ave., Balboa, Calif.; Vice president, marketing, Sierra Engineering Co., Sierra Madre, Calif.; Trng.—Engineering; Int.—Anesthesia & surgical equipment, anthropomorphic dummies, prostheses.

ROEBUCK, JOHN A., 12679 Stanwood Dr., Los Angeles 66, Calif.; B.S. 1952 (Mechanical Engineering); Designer, Human Factors Group, Interior Design Section, Engrg. Dept., A250 Douglas Aircraft Co., Inc., 3000 Ocean Park Blvd., Santa Monica, Calif.; Trng.—Engineering design; Int.—Anthropometry, workspace layout, ground escape systems.

ROGERS, MILES S., 9412 Isis Ave., Los Angeles, Calif.; Ph.D. 1952 (Psychology); Human Factors Scientist, Research Staff, Human Factors Directorate, System Development Corporation, 2500 Colorado Ave., Santa

Monica, Calif.; Trng.—Experimental psychology; Int.—System training, system design, information theory.

ROMANO, SAMUEL, 11 Park Place, Paramus, N.J.; B.S. 1951 (Mechanical engineering); Program Manager, Engineering Dept., Avion Div., A.C.F. Industries, Inc., 11 Park Place, Paramus, N.J.; Trng.—Military systems; Int.—Display requirements and integrated display systems.

ROSCOE, S. N., 8073 Kentwood Ave., Los Angeles 45, Calif.; Ph.D. 1950 (Psychology); Head, Human Factors Engineering, Airborne Systems Laboratories, Hughes Aircraft Co., Culver City, Calif.; Trng.—Aviation Engineering psychology; Int.—Control-display-systems analysis, research, design.

ROSHAL, SOL M., 175 Granville Ave., Los Angeles 49, Calif.

ROSS, DONALD M., Div. of Biology & Medicine, U.S. AEC, Washington 25, D.C.; ScD. 1956 (Industrial hygiene); Industrial hygienist, Div. of Biology & Medicine, U.S. Atomic Energy Commission, Washington 25, D.C.; Trng.—Industrial hygiene; Int.—Biomechanics, toxicology.

ROTH, HERMAN P., 211 Anderson St., Manhattan Beach, Calif.

ROWEN, BURT, 11 16th St., Edwards, Calif.; M.D. 1945; Chief, Human Factors Branch, Air Force Flight Test Center, Edwards Air Force Base, Calif.; Trng.—Aviation medicine—flying; Int.—Aeromedical support, weapon systems, research aircraft.

ROWLAND, GEORGE E., P. O. Box 61, Haddonfield, N.J.; Ph.D. 1951 (Psychology); President, Rowland & Co., P. O. Box 61, Haddonfield, N.J.; Trng.—Psychology; Int.—Operations research, systems analysis, and human factors.

RUDIGER, THOMAS F., Sperry Gyroscope Co., Great Neck, N.Y.

SAMPSON, PHILIP B., c/o Dept. of Psychology, Tufts University, Medford 55, Mass.; Ph.D. 1957 (Psychology); Assistant Professor, Dept. of Psychology, Tufts University, Medford 55, Mass.; Trng.—Psychology; Int.—Vision, instrumentation, control dynamics, training.

SANBORN, JOSEPH G. Y., 768 Upsal St., S.E., Washington 20, D.C.; LCDR; Educational Psychologist, Naval Gun Factory, Naval Weapons Plant, Personnel Research-Code 153, Washington 25, D.C.; Trng.—Training Director; Int.—Personnel logistics and research in guided missiles.

SANTSCHI, WILLIAM R., 2119 N. Beverly Glen Blvd., Los Angeles, Calif.

SAUL, EZRA V., 11 Briar Lane, Marblehead, Mass.; Ph.D. 1951 (Psychology); Director, Institute for Applied Experimental Psychology, Tufts University, Medford 55, Mass.; Trng.—Experimental Psychology; Int.—Human factors documentation and training.

SAUL, FRANK P., Peabody Museum, Harvard University, Cambridge 38, Mass.; M.A. 1953 (Anthropology); Physical Anthropologist, Anthropology Branch, EPRD, U.S. Army QM R&E Center Laboratories, Natick, Mass.; Trng.—Anthropology; Int.—Anthropometry, personal equipment sizing, workspace layout.

SCHMITZ, MELVIN A., 133 W. Oregon St., Milwaukee 4, Wis.; Ph.D. 1954 (Experimental Psychology); Chief Engineering Psychologist, Bostrom Research Laboratories, Division Bostrom Corporation, 133 W. Oregon St., Milwaukee 4, Wis.; Trng.—Experimental Psychology, Minors in Physiology and Math.; Int.—Effect of vibration and jolt on human response.

SCHNEIER, HOWARD, 262 Garfield Ave., Collingswood, N.J.; M.A. 1957 (Psychology); Human Factors Engineer, Missile & Surface Radar Dept.—Defense Electronic Products, Human Factors Engineering, Radio Corporation of America, Moorestown, N.J.; Trng.—Mechanical Engineering.

SCHOHAN, BENJAMIN, 398 Catawba Ave., Westerville, Ohio; M.A. 1950 (Industrial Psychology); Engineering Specialist, Attack Projects, North American Aviation, Inc., Columbus Division, E. Fifth Ave., Columbus 16, Ohio; Int.—Systems requirements, design, training, training equipment.

SCHROEDER, ARTHUR H., 23 Birch Drive, Beacon, N.Y.; B.M.E. 1950 (Mechanical Engineering); Associate Engineer, Data Processing Division, IBM Corporation, P.O. Box 390, Poughkeepsie, N.Y.; Trng.—Engineering, Mechanical; Int.—Applied human factors.

SCHULZE, VICTOR E., JR., USAF School of Aviation Medicine, Brooks AFB, Texas; M.D. 1954 (Medicine) M.I.H., 1959 (Industrial Hygiene); Flight Surgeon (Captain), U.S. Air Force; Trng.—Aviation Medicine; Int.—Flight test, aviation toxicology.

SCHUSTER, DONALD H., Psychology Dept., University of Southern California, Los Angeles 7, Calif.

SCHUTZ, HOWARD G., 505 King, Columbus, Ohio; Ph.D. 1955 (Psychology); Research Psychologist, Systems Engineering Division, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio; Trng.—Physiological and Experimental Psychology; Int.—Man-machine systems, visual displays.

SEITZ, CLIFFORD P., Dolphins Rise, Lloyd Neck L.I., N.Y.; Ph.D. 1939 (Psychology); Chief, Human Factors, Grumman Aircraft Engineering Corp., Bethpage, L.I., N.Y.; Trng.—Psychology; Int.—Vision, high altitude, displays, training, aviation psychology.

SEVERY, DERWYN M., 3329 Tarece Dr., Hollywood 28, Calif.

SHAFER, PHILIP S., WADC Area B, Box 8123, Wright-Patterson AFB, Ohio; M.A. 1952 (Psychology); Assistant Chief (Major), Human Factors Branch, AF Flight Test Center, Edwards AFB, Calif.; Int.—Aircrew stations.

SHEA, JAMES J., 3502 Pringle St., San Diego 1, Calif.; M.A. 1958 (Psychology); Instructor, San Diego Junior College, San Diego, Calif.; Employment Consultant, Reese Graves & Associates, Bank of America Bldg., San Diego, Calif.; Trng.—Applied-Industrial Psychology, Teaching, and Research; Int.—Verbal communications, complex system reliability, psychology.

SHEARER, JAMES W., 12827 Occidental, Seattle 88, Wash.

SHELTON, SID WATTS (Cdr. USN, Ret.); 3020 Meier Place, Cuyahoga Falls, Ohio; B.S. 1941 (Mechanical Engineering); Senior Development Engineer, Aeromechanics, Research and Development, Goodyear Air-

craft Corp., Akron, Ohio; Trng.—Flight Safety, Naval Aviator; Int.—Human factors, equipment, flight safety.

SHERIDAN, THOMAS B., 77 Massachusetts Ave., Cambridge 39, Mass.; Sc.D. 1959; Mechanical Engineer, Massachusetts Institute of Technology, Cambridge, Mass.; Trng.—Systems Engineering, Experimental Psychology; Int.—Systems engineering, experimental psychology.

SHOENBERGER, LARRY THOMAS, 963 Shauna Lane, Palo Alto, Calif.

SIDORSKY, RAYMOND C., Human Factors Section, Electric Boat Division, General Dynamics Corp., Groton, Conn.; Ph.D. 1954 (Psychology); Head, Human Factors Section, Electric Boat Division, General Dynamics Corp., Groton, Conn.; Trng.—Engineering Psychology; Int.—Engineering psychology.

SIDOWSKI, JOSEPH B., San Diego State College, San Diego, Calif.; Ph.D. 1956 (Psychology); Associate Professor, Psychology Department, San Diego State College, San Diego, Calif.; Trng.—Experimental Psychology; Int.—Engineering psychology, experimental design, statistics, aero-space.

SIEGEL, A. I., 165 Hillside Circle, Villanova, Pa.

SILLMAN, GERARD I., 1619 Gratton St., Riverside, Calif.; B.S.E.E. 1948 (Electronics); Human Factors Engineer, Systems Research Laboratory, Motorola Inc., 8330 Indiana Ave., Riverside, Calif.; Trng.—Human Factors Aspects of Systems Design; Int.—Operational evaluation, system specifications, performance analysis.

SIMON, CHARLES W., 1030-F 5th St., Santa Monica, Calif.; Ph.D. 1950 (Psychology); Staff Engineer, Human Factors Engineering Section, Hughes Aircraft Company, Culver City, Calif.; Trng.—Engineering Psychology; Int.—Equipment design, research techniques; bioelectronics; sleep.

SIMON, GEORGE B., Lauderdale Dr. MR 98, Binghamton, N.Y.; Ed.D. 1953 (Research and Evaluation); Chief, Engineering Psychology Dept., Binghamton Laboratory, Link Aviation, Inc., Binghamton, N.Y.; Trng.—Psychology & Education; Int.—Training, training devices, evaluation, display-control relationships.

SIMONS, ALLISON K., 5826 N. Lake Drive, Milwaukee 17, Wis.; B.S. (1950) (Mechanical Engineering); Director, Bostrom Research Laboratories, Bostrom Corp., 133 W. Oregon, Milwaukee 4, Wis.; Trng.—M.E.; Int.—Environmental stress, vehicular seating.

SKLODOWSKI, VLADIMIR A., Human Factors Engineering Group, AVCO Corp., Crosley Division, 1329 Arlington St., Cincinnati 25, Ohio; Ph.D. 1951 (Psychology); Manager, Human Factors Engineering Group, Crosley Division, AVCO Corporation, 1329 Arlington St., Cincinnati 25, Ohio; Trng.—Psychology; Int.—Human engineering, system analysis and synthesis.

SLEIGHT, ROBERT B., 715 North St., Falls Church, Va.; Ph.D. 1949 (Psychology); President, Applied Psychology Corp., 4113 Lee Hwy., Arlington, Va.; Trng.—Industrial and Experimental Psychology; Int.—Human engineering administration, research, and consulting.

SLOCUM, GERALD K., 5893 West 74th St., Los Angeles 45, Calif.; M.S. 1958 (Biotechnology); Head, Functional Design Group, Human Factors Engineering Section, Advanced Development, Hughes Aircraft Co., Florence & Teale, Culver City, Calif.; Trng.—Engineering; Int.—Control, display, system design.

SLOTE, LAWRENCE, 1245 Findlay Ave., New York 56, N.Y.; M.M.E. 1948 (Engineering); Research Scientist, Research Division, College of Engineering, New York University, 181st St. & University Ave., Bronx 53, N.Y.; Trng.—Engineering (Mechanical & Sanitary); Int.—Biomechanics and Environmental control of closed ecological systems.

SMALL, ARNOLD M., SR., 6619 Aranda Ave., La Jolla, Calif.; Ph.D. 1936 (Psychology); Manager, Reliability & Quality Assurance Laboratory, Hughes Aircraft Co., Fullerton, Calif.; Trng.—Psychology, Mathematics, Music; Int.—Psycho-acoustics, systems analysis, program development-administration.

SMITH, B. J., East Sullivan, N.H.

SMITH, WELLINGTON E., Dept. 577, IBM, Kingston, N.Y.; M.S. 1952 (Psychology); Staff Psychologist, Human Factors Group, Dept. 577, International Business Machines Corp., Kingston, N.Y.; Trng.—Psychology; Int.—Display systems, tracking, maintenance, programming.

SNYDER, DAVID M., 120 W. Genesee St. Atlantic Bldg., Syracuse, N.Y.; M.A. 1952 (Psychology and Mathematics); Project Engineer of Personnel and Training, Defense Systems Department, Systems Operational Engineering Sec., General Electric Co., Atlantic Building, Syracuse, N.Y.; Trng.—Experimental Psychology; Int.—Job analysis, unit proficiency evaluation, training.

SNYDER, MONROE B., 250 Ridge Ave., State College, Pa.; M.A. 1955 (Psychology); Senior Psychologist, HRB-Singer Inc., Science Park, State College, Pa.; Trng.—Industrial Psychology; Int.—Man-machine analysis, personnel requirements.

SNYDER, RICHARD G., 7021 Opatas Pl., Tucson, Ariz.; Ph.D. 1959 (Physical Anthropology); Research Associate, Applied Research Laboratory, University of Arizona, Tucson, Ariz.; Trng.—Physical Anthropology (Human Biology); Int.—Deceleration, escape, restraint, systems, workspace design.

SONTAG, HARCOURT, 4717 37th St., N., Arlington 7, Va.

SPAULDING, ROY H., P. O. Box 12, Bryan, Ohio; B.S. 1950 (Mechanical and Administrative Engineering); Chief Engineer, Bryan Aircraft Division, The Aro Equipment Corp., Bryan, Ohio; Trng.—Engineering; Int.—Life support aircraft, manned space vehicles.

SPERLING, HERBERT, 115 N. Eastwood Ave., Inglewood 1, Calif.; Ph.D. 1928 & 1957 (Psychology); Clinical Psychologist, 301 E. Regent St., Inglewood, Calif.; Psychologist & Optical Engineer, Northrop Aircraft, Inc., Hawthorne, Calif.; Trng.—Psychology, Engineering; Int.—Psychology.

SPICKARD, WILLIAM, 587 Balsam, Sunnyvale, Calif.

SPRAGG, S. D. SHIRLEY, University of Rochester, Rochester 20, N.Y.; Ph.D. 1935 (Experimental Psychology); Professor of Psychology and Dean of Graduate Studies, University of Rochester, Rochester 20, N.Y.; Trng.—Experimental Psychology; Int.—Perceptual-motor relationships in performance.

STAHL, JOSEPH I., 7624 Flight Ave., Los Angeles, Calif.; M.A. 1957 (Psychology); Engineering Psychologist, Engineering Dept., North American Avia-

tion Inc., International Airport, Los Angeles, Calif.; Trng.—Psychology; Int.—Man-machine relationships in weapon system design.

STANNARD, RALPH, Box 24583, Los Angeles 24, Calif.

STASINOS, NICK G., 5450 West 83rd St., Los Angeles 45, Calif.

STECH, ERNEST L., 976 Francis Ave., Columbus, Ohio; A.B. 1956 (Psychology); Research Engineer, Human Factors, Engineering Division, North America Aviation, Columbus Division, 4500 E. Fifth Ave., Columbus, Ohio; Trng.—Psychology; Int.—Cockpit design, task analysis.

STIEGLITZ, WILLIAM I., 274 West Neck Rd., Huntington, N.Y.; B.S. 1932 (Aeronautical Engineering); Chief of Design Safety and Reliability, Republic Aviation Corp., Farmingdale, N.Y.; Trng.—Engineering; Int.—Aircraft, accident prevention.

STONE, GERALD, 2501 Nostrand Ave., Brooklyn 10, N.Y.; B.Aero.E. 1949 (Engineering); Research Scientist, College of Engineering, Research Div., New York University, 252 Seventh Ave., New York 1, N.Y.; Trng.—Aeronautical Engineering; Int.—Biomechanics.

STOYANOFF, LOUIS J., 23171 Bigler St., Woodland Hills, Calif.; M.A. 1949 (Psychology); Senior System Engineer, Hoffman Laboratories Division, Hoffman Electronics Corp., Los Angeles, Calif.; Trng.—Physiological Psychology; Int.—Sensation, perception, skills and system training.

SUSSER, LESTER L., 119 So. Normandie Ave., Los Angeles, Calif.; B.A. 1953 (Psychology); Director, Human Factors Program (Eagle Missile System), Systems Division, Bendix Aviation Corp., 14617 Keswick St., Van Nuys, Calif.; Trng.—Graduate Engineering Psychology, USAF Pilot; Int.—Aircraft, missiles, space systems design development.

SVENSON, DONALD W., 5542 Keokuk Ave., Woodland Hills, Calif.; B.A. 1947 (Psychology); Research Engineer, Dept. 33, Tactical Systems Laboratory, Litton Industries, 336 N. Foothill Rd., Beverly Hills, Calif.; Trng.—Experimental Psychology; Int.—Human engineering in systems development.

SWAIN, ALAN D., Dunlap & Assoc., Inc., 429 Atlantic St., Stamford, Conn.; Ph.D. 1953 (Psychology); Senior Psychologist, Dunlap and Associates, Inc., 429 Atlantic St., Stamford, Conn.; Trng.—Ohio State Univ.; Int.—Systems analysis, human engineering, technical training.

SWEARINGEN, JOHN J., Box 1082 Oklahoma City, Okla.; M.S. 1937 (Human Physiology); Chief, Civil Aeronautics Medical Research Laboratory, Federal Aviation Agency, P.O. Box 1082, Oklahoma City, Okla.; Trng.—Aviation Physiology; Int.—Human capabilities in relation to safety.

SWEDA, MICHAEL, P. O. Box 9893, Arlington Heights, Fort Worth 7, Texas.

TAIT, JAMES F., 16121 Alcima, Pacific Palisades, Calif.; Ph.D. 1956 (Clinical Industrial Psychology); Human Factor Scientist, Section Head, SCP Human Factors Research and Support Section, System Development Corp., 2500 Colorado St., Santa Monica, Calif.; Trng.—Clinical and Industrial Psychology; Int.—Human factors problems, data processing systems.

TALALAY, ANSELM, 131 West Park Ave., New Haven, Conn.; M.S. 1934 (Physical Chemistry); General Manager, B. F. Goodrich Sponge Products Division, B. F. Goodrich Company, Shelton, Conn.; Trng.—Physics and Chemistry of Rubber; Int.—Applications of cellular rubber and plastics.

TARR, JOHN S., 4874 East Cooper, Tucson, Ariz.; M.A. 1955 (Anthropology); Anthropolgist, Group Head, Tucson Engineering Laboratories, Hughes Aircraft Co., P. O. Box 11337, Tucson, Ariz.; Trng.—Anthropology; Int.—Work space, space environment, crash injury.

TAYLOR, FRANKLIN V., 4441 So. 31st St., Arlington 6, Va.; Ph.D. 1936 (Psychology); Head, Engineering Psychology Branch, U. S. Naval Research Laboratory, Washington 25, D.C.; Trng.—Experimental Psychology; Int.—Control systems, vigilance, system design.

TEEL, KENNETH S., 6511 Driscoll St., Long Beach 15, Calif.; Ph.D. 1950 (Psychology); Head, Human Factors Group, Autonetics, Dept. 386-93, 9150 E. Imperial Highway, Downey, Calif.

TEICHNER, WARREN H., Dept. of Psychology, University of Massachusetts, Amherst, Mass.; Ph.D. 1951 (Psychology); Assoc. Prof. of Psychology, Dept. of Psychology, University of Massachusetts, Amherst, Mass.; Trng.—Experimental Psychology; Int.—Environmental factors, visual perception, motor performance.

THURLOW, VIRGIL S., c/o System Development Corp., P. O. Box 302, Lodi, N.J.; M.S. 1955 (Physics); Assistant to Division Manager, SACCS Division, System Development Corp., P.O. Box 302, Lodi, N.J.; Trng.—Physics; Int.—Large computer based man-machine systems.

TIPTON, ROBERT R., P. O. Box 584, Berkeley 1, Calif.; B.S. 1950 (Electrical Engineering); Electrical Engineer (self-employed), P. O. Box 584, Berkeley 1, Calif.; Trng.—Electrical Engineering-Industrial Design; Int.—Product design.

TOBIAS, PAUL R., 404 So. Hamel Rd., Los Angeles 48, Calif.; B.A. 1955 (Psychology); Human Centrifuge of University of Southern California, Los Angeles, Calif.; Int.—Physiological and psychological measurement of human behavior.

TRABOLD, FREDERICK W., 6108 Joyce Lane, Cincinnati 37, Ohio; M.A. 1950 (Psychology); Advanced Research Engineer, Human Factors Engineering Group, Crosley Division. AVCO Corporation, 1329 Arlington St., Cincinnati 25, Ohio; Trng.—Experimental Psychology; Int.—Human engineering design, human factors experiments.

VAN COTT, HAROLD P., Ph.D. 1954 (Psychology); Manager, Human Factors, Federal Systems Div., Dept. 594, I.B.M., Kingston, N.Y.; Trng.—Experimental Psychology; Int.—Development of data-processing and military systems.

VANDENBERG, JOHN D., 3757 Locust Ave., Seaford, N.Y.; M.A. 1953 (Psychology); Human Factors Specialist, Human Factors Group, Systems Design Department, Grumman Aircraft Engineering Corp., Bethpage, N.Y.; Trng.—Psychology; Int.—Systems analysis, perceptual and motor skills.

VOAS, R. B., Human Factors Branch, Space Task Group, NASA, Langley Field, Va.

WAGGONER, JAMES N., Medical Director, The Airresearch Co., 9851 So. Sepulveda, Los Angeles 45, Calif.

WALKER, JOSEPH H., 3900 Via Pavion, Palos Verdes Estates, Calif.

WARREN, NEIL D., Department of Psychology, University of Southern California, Los Angeles 7, Calif.

WASSERMAN, WALTER L., 14 Caton Dr., East Syracuse, N.Y.; B.A. 1957 (Psychology); Human Factors Specialist, Defense Electronics Division, HMEED, General Electric Corp., Syracuse, N.Y.; Int.—Vision, audition, ambiant conditions, displays, learning.

WATSON, WARREN N., 3217 5th West, Seattle 99, Wash.; M.A. 1934 (Psychology-Education); Chief, Human Factors Unit, Reliability Staff, Transport Division, Boeing Airplane Co., Renton, Wash.; Trng. —Psychology; Int.—Flight control displays, subjective response-poise.

WEBB, PAUL, Box 51, Yellow Springs, Ohio; M.D. 1946 (Medicine); Consultant (self-employed), Box 51, Yellow Springs, Ohio; Trng.—Environmental and Aviation Physiology; Int.—Environmental physiology, aerospace medicine.

WEISLOGEL, ROBERT L., 612 Meigs Rd., Santa Barbara, Calif.; Ph.D. 1951 (Psychology); Director (Western Office), American Institute for Research, 810 Granada Bldg., 216 State St., Santa Barbara, Calif.; Trng.—Industrial Psychology; Int.—Systems, operations analysis.

WELDON, ROGER J., 6025 San Leandro, Tucson, Ariz., Ph.D. 1952 (Psychology); Research Psychologist, Applied Research Laboratory, University of Arizona, Tucson 25, Ariz.; Trg.—Experimental Psychology; Int.—Human error in routine tasks.

WELLS, J. GORDON, 10712 Fifth Ave., Inglewood, Calif.; Ph.D. 1951 (Biological Sciences); Supervisor, Human Engineering and Equipment Design, Northrop Corp., Noair Division, 1001 East Broadway, Hawthorne, Calif.; Trng.—Biological Sciences; Int.—Aviation Physiology.

WELTMAN, GERSHON, 902 S. Ogden Dr., Los Angeles, Calif.; B.S. 1958 (Engineering); Graduate Research Engineer, UCLA Dept. of Engineering, University of California, Los Angeles 24, Calif.; Trng.—Engineering; Int.—Information handling systems, humans and computers.

WHEELER, DOUGLAS E., 1315 West Ave. J-2, Lancaster, Calif.; Ph.D. 1949 (Audiology); Research Engineer, Liaison Engineering, Convair Div. of General Dynamics, Palmdale Facility, Palmdale, Calif.; Trng.—Psychology, bio-acoustics; Int.—Reliability.

WHITLOCK, COLEMAN M., 718 W6 South St., Brigham City, Utah.

WHITNEY, CLAIR G., 10931 Rainier Ave., Seattle 88, Wash.

WICKETT, JOHN C., Director of Aviation Medicine, Air Force Headquarters, Ottawa 4, Ontario, Canada; M.S. 1950 (Biochemistry); Trng.—Medical; Int.—Bioscience.

WILKENING, GEORGE M., Industrial Hygienist, Esso Standard Oil Co., P. O. Box 222, Linden, N.J.

WILLIAMS, GLENN H., 5422 W. 82nd St., Los Angeles 45, Calif.

WILLIAMS, HERMAN L., 3000 Arlington Blvd., Falls Church, Va.; A.B. 1949 (Mathematics, Physics); Supervisor, Human Factors Engineering, Melpar, Inc., 3000 Arlington Blvd., Falls Church, Va.; Trng.—Mathematics, Physics; Int.—Human factors in equipment design.

WILLIS, HAROLD R., 11 Media Dr., Creve Coeur, Mo.; M.A., M.S. 1954, 1955 (Education, Psychology); Senior Operations Analyst, Missile Engineering Div., Dept. 460, McDonnell Aircraft Corp., Lambert-St. Louis Airport, St. Louis 3, Mo.; Trng.—Electronics Engineering, Education, Psychology; Int.—Design of controls and control panels.

WILSON, CLARK L., 383 Madison Ave., New York 17, N.Y.; Ph.D. 1948 (Psychology); Vice-president, Research Dept., Batten, Barton, Durstine & Osborn, 383 Madison Ave., New York 17, N.Y.; Trng.—Psychology.

WISE, FRED H., 202 Crestwood Rd., Smyrna, Ga.; M.Ed. 1956 (Personnel); Social Scientist, Human Factors, System Development Corp., 2500 Colorado Ave., Santa Monica, Calif.; Trng.—Guidance and Personnel; Int.—Personnel training, placement in automated system.

WITTECK, FRANK A., 78-22 84th St., Glendale 27, NYC, New York; B.M.E. 1948 (Engineering); Chief, Limb and Brace Section, V.A. Prosthetics Center, Veterans Administration, 252 7th Ave., NY 1, N.Y.; Trng.—Engineering; Int.—Research in prosthetics and orthotics.

WOLBERS, HARRY L., 218 Via Pasqual, Redondo Beach, Calif.; Ph.D. 1955 (Psychology); Assistant Chief, Equip. & Safety Research Section, Engineering Dept., El Segundo Division, Douglas Aircraft, El Segundo, Calif.; Trng.—Electrical Engineering and Psychology; Int.—Control dynamics, information displays, mathematical models.

WOLIN, BURTON R., 17 Bertwell Road, Lexington 73, Mass.

WOLPE, GERSON L., 1674 Northwood Apts., Ann Arbor, Michigan; B.S. 1958 (Industrial engineering); Research Assistant, Dr. Paul M. Fitts, University of Michigan, Ann Arbor, Michigan; Trng.—Industrial Engineering; Int.—Performance of man-machine systems.

WONG, WILSON, 8703 Latijera Blvd., Los Angeles, Calif.; M.A. 1955 (Experimental Psychology); Scientist, Systems Planning & Evaluation, Kellogg, Communication Division of I.T.&T., 8703 Latijera Blvd., Los Angeles, Calif.; Trng.—Psychology.

WOODHAM, ROLAND M., 181 Pasadena Place, Hawthorne, N.J.; B.S. 1926 (Engineering); Associate Director, Cornell-Guggenheim Aviation Safety Center, 468 Fourth Ave., New York 16, N.Y.; Trng.—Engineering and Administrative; Int.—Aviation safety.

WOODSON, W. E., JR., 2026 Willis Road, El Cajon, Calif.

WORLEY, MILTON S., 1519 Perkins Way, Seattle 55, Wash.; M.A. 1952 (Psychology); Research Engineer, Human Factors, Boeing Airplane Company, Seattle 14, Wash.; Trng.—Psychology; Int.—Equipment design.

WORTZ, EDWARD C., 4656 Mississippi, San Diego, Calif.; Ph.D. 1957 (Experimental Psychology); Senior Research Engineer, Astronautics, Convair, San

Diego, Calif.; Trng.—Experimental psychology; Int. —Information theory of space biotechnology.

WRIGHT, NATALIE LOUISE, 8 Lansing Place, Montclair, N.J.

WULFECK, JOSEPH W., 1532 Third St., Santa Monica, Calif.; Ph.D. 1952 (Psychology); Resident Manager-Program Director, Dunlap and Associates, 1532 Third St., Santa Monica, Calif.; Trng.—Experimental and Physiological Psychology; Int.—Human Engineering: Vision and visual displays.

YOUNG, JOSEPH W., 9713 Felton Ave., Inglewood, Calif.; M.A. 1960 (Physical Anthropology and Anatomy); Research Engineer, Anthropologist, Human Factors Group, Physiology, North American Aviation, International Airport, Los Angeles 45, Calif.; Int.—Biomechanics and functional anatomy.

ZELENY, CHARLES E., 2435 Indian Ridge Dr., Tucson, Ariz.; M.A. 1953 (Psychology); Program Director, Tucson Div., Applied Psychology Corp., 4113 Lee Hwy., Arlington 7, Va.; Trng.—Research Psychology; Int.—Experimental design, systems research.

ZEPP, WILBUR J., President, Zep Aero, 113 Sheldon St., El Segundo, Calif.

ZIEDMAN, KENNETH, Dept. of Psychology, University of California, Los Angeles 24, Calif.

ZIMMERMAN, R. J., 2227 Kellogg Park Drive, Pomona, Calif.

Geographical List of Members

AUSTRALIA

BAXTER, J. Russel
CUMMING, Ronald W.

CANADA

HEINES, J. M. H.
HOYT, Ruth
LEWIS, R. E. F.
MACKWORTH, Norman H.
WICKETT, John C.

GREAT BRITAIN

MAXWELL, Ian R.

SWEDEN

NORDSTROM, K. Lennart

UNITED STATES

Alabama

KAPNER, William S.

Arizona

CARRIGER, Barbara K.
HASBROOK, A. Howard
SNYDER, Richard G.
TARR, John S.
WELDON, Roger J.
ZELENY, Charles E.

California

ADAMS, Bertram B.
ADELSON, Marvin
ALEXANDER, Lawrence T.
ANDREWS, F. G.
ARNOLD, John E.
ATKINS, Dale L.
ATKINS, David W.
BARNES, Kischel M.
BARRON, Charles I.
BEAM, R. Atlee
BEKEY, George A.
BENNETT, William F.
BERRY, Herbert A.
BIEL, William C.
BLANCHARD, William H.
BLOCKLEY, W. Vincent
BLOOM, Aaron
BOND, Nicholas A.
BRANNAN, Max
BRIGGS, Stewart J.
BROWN, D. W.
BRYAN, G. L.
BUCKNER, Donald N.
CAROTHERS, O. E.
CART, Hugh
CARTER, Charles W.
CARTER, Launor F.
CATRAN, Jack
CELENTANO, John T.
CHAPIN, R. G.
CHRISTENSEN, Paul R.
CLEGG, Donald A.
COBURN, Richard
COLLIER, Douglas R.
COLLINS, Lloyd R.
COLSON, Kenneth R.
CONKLIN, Jack E.
CONOVER, Donald W.
COOPER, J. I.
COOPER, Wilfred N.
CORNWALL, Ellsworth W.
CUNNINGHAM, Clairdon E.
DAVIS, Robert A.
DEAN, Edward L.
DETAMBEL, Marvin H.
DOUGLAS, Riley E., Jr.
DOUGLAS, W. A.
ESCH, Lynd J.
EVANS, William E.
FAUBION, Richard W.
FERGUSON, L. G.
FINK, Joseph
FOGEL, A.
FOGEL, Lawrence J.
FREEDMAN, Toby
GARTNER, Walter B.
GERSHON, Arthur
GIARRETTO, Henry
GIFFORD, Robert N.
GLASSNER, Harvey F.
GOLDBERG, Marvin N.
GOLDEN, Sanford S.
GORDON, Jerome J.
GREEN, Kenneth E.
GRINGS, William W.
GROTH, Hilde
GRUNDEMAN, Fred D.
HALL, Albert C.
HALTOM, Paul T.
HAMBURGER, Charles D.
HANIFAN, Donald T.
HARKEY, Gabriel J.
HARSH, Charles M.
HEGLIN, Howard J.
HIGHLAND, Richard W.
HIRSCH, Richard S.
HOFFMAN, Lyle S.
HOPKINS, Charles O.
HOYT, William G.
HULBERT, Slade F.
HUSSMAN, Thomas A., Jr.
ISHERWOOD, John David
JACOBS, Howard I.
JARRETT, Hilton F.
JENSEN, Lennard V.
JOHNSON, Charles W.
JOHNSON, George H.
JONES, L. N.
KACH, Peter H.
KENYON, Wilfred
KINZER, John R.
KNACKE, Theodore W.
KNIGHT, Richard W.
KONECCI, Eugene B.
LA PORTE, Harold R., Jr.
LAW, Howard C.
LAYMON, Richard S.
LEFRITZ, Norman M.
LEVEDAHL, Blaine H.
LEWIS, William L.
LIPPERT, Stanley
LOMBARD, C. F.
LYMAN, John
MAC CASLIN, Eugene F.
MACKIE, R. R.
MANGELSDORF, John E.
MARANO, Joseph A.
MATHEWSON, John H.
MCCORMICK, William G.
MCCORNACK, Robert L.
MCCUTCHAN, Joseph W.
MCDONALD, J. F.
MARZOCCO, Frank N.
MEEHAN, John P.
MINNEY, Orval H.
MITCHELL, Meredith B.
MOREHOUSE, Laurence E.
MORGAN, LaVerne E.
MOWER, Ralph D.
MURPHY, Edward A., Jr.
NADEL, Aaron B.
NEUMANN, Harold L.
NEWMAN, Paul H.
NICHOLS, Daryl G.
O'CONNELL, Eugene R.
OEHRLEIN, Thomas F.
OETTINGER, L., Jr.
OKANES, Marvin M.
PARKER, Robert N.
PARSONS, Henry M.
PASKUSZ, Gerhard F.
PAYNE, Thomas A.
PENN, Robert
PETERS, George A.
POPPEN, John R.
PRICE, Harold E.
RABIDEAU, Gerald F.
RAPPAPORT, M.
REHMAN, Irving
RICHLAND, Malcolm
RITTERRATH, F. Arthur
ROEBUCK, John A.
ROGERS, Miles S.
ROSCOE, S. N.
ROSHAL, Sol M.
ROTH, Herman P.
ROWEN, Burt
SANTSCHI, William R.
SCHUSTER, Donald H.
SEVERY, Derwyn M.
SHAFER, Philip S.
SHEA, James J.
SHOENBERGER, Larry Thomas
SIDOWSKI, Joseph B.
SILLMAN, Gerald I.
SIMON, Charles W.
SLOCUM, Gerald K.
SMALL, Arnold M., Sr.
SPERLING, Herbert
SPICKARD, William

STAHL, Joseph L.
STANNARD, Ralph
STASINOS, Nick G.
STOYANOFF, Louis J.
SUSSER, Lester L.
SVENSON, Donald W.
TAIT, James F.
TEEL, Kenneth S.
TIPTON, Robert R.
TOBIAS, Paul R.
WAGGONER, James N.
WALKER, Joseph H.
WARREN, Neil D.
WEISLOGEL, Robert L.
WELLS, J. Gordon
WELTMAN, Gershon
WILLIAMS, Glenn H.
WOLBERS, HARRY L.
WONG, Wilson
WOODSON, W. E., Jr.
WORTZ, Edward C.
WULFECK, Joseph W.
YOUNG, Joseph W.
ZEPP, Wilbur J.
ZIEDMAN, Kenneth
ZIMMERMAN, R. J.

Colorado

BEHAN, Richard A.
DAVIS, Robert H.
FINK, John B.
MUCKLER, Frederick A.

Connecticut

DUNLAP, Jack W.
ECKENRODE, Robert T.
ESTRINE, Lewis
HARKINS, William H.
ORLANSKY, Jesse
SIDORSKY, Raymond C.
SWAIN, Alan D.
TALALAY, Anselm
WILSON, Clark L.

District of Columbia

CHEATHAM, Paul G.
GAYLORD, Richard H.
KURKE, Martin I.
LUND, Max W.
ROSS, Donald M.
SANBORN, Joseph G.

Florida

BERRIDGE, Harold L.
BUSHONG, Albert J.
CHALMERS, E. Laurence, Jr.
FLEXMAN, Ralph E.
HELVEY, T. C.
LEADINGHAM, Robert L.
LINDSEY, Jefferson Franklin

Georgia

ADAMS, Oscar S.
FOLLETTIE, J. F.
KRAFT, Jack A.
WISE, Fred H.

Illinois

COHEN, Harold L.
HURT, G. Rex
LORENZ, E. Theodore
PERNINI, Henry M.

Indiana

MCCORMICK, Ernest J.

Iowa

ALLISON, Byron L.

Kansas

BEAUPEURT, Joseph E.

Maryland

ANSON, William H.
CORNOG, Douglas Y.
CHAPANIS, Alphonse
DUDDY, John H.
ERSKINE, Donal G.
FIGHTMASTER, Walter J.
FRIED, Charles
GLOVER, J. Frank
GOODMAN, Irving B.
HARDESTY, George K. C.
HAZELL, Joseph W.
KAHN, Arthur
KING, Barry G.
MCGOVERN, Thomas F.
MERKIN, Allan
PETTY, G. R., Jr.
NICKLAS, Douglass R.
PLANT, Jane
RHOADES, Marion V.

Massachusetts

BERANEK, Leo L.
COULES, John
CUTTING, Ralph C., Jr
DAMON, Albert
DEVOE, Donald B.
DOMEY, Richard
DUNCAN, Richard D. P.
ELKIND, J. I.
HICKEY, Albert E.
KRYTER, Karl D.
LEE, Francis J.
LICKLIDER, J. C. R.
LITTLE, Henry
MASON, RAIGH
MCFARLAND, Ross A.
MEAD, Leonard C.
MORGAN, Conrad J.
SAMPSON, Philip B.
SHERIDAN, Thomas B.
TEICHNER, Warren H.
SAUL, Ezra V.
SAUL, Frank P.
WOLIN, Burton R.

Michigan

FINKELSTEIN, Stanley
FITTS, Paul M.
FLOOD, Merrill M.
FORBES, Theodore W.
GORDON, Donald A.
JENSEN, Leonard L.
KYROPOULOS, Peter
LEARNER, David B.
MCCLERNAN, M.
MELTON, Arthur W.
WOLPE, Gerson L.

Missouri

FARRIS, Herbert J.
WILLIS, Harold R.

Nebraska

ANDERSON, George R.

New Hampshire

SMITH, B. J.

New Jersey

BARKER, Herbert, Jr.
EPSTEIN, Sidney P. O.
GOODWIN, W. Richard
HOLLABAUGH, J. F.
HOLSTEIN, David
HUEBNER, Daniel L.
KARLIN, John E.
KULP, Charles M.
LINSKEY, Joseph W.
MAYRAND, Fred R.
MAYZNER, Mark S.
MARSHALL, T. A., Jr.
NESTOR, George
RIESZ, Robert R.
ROMANO, Samuel
ROWLAND, George E.
SCHNEIER, Howard
THURLOW, Virgil S.
WILKENING, George M.
WOODHAM, Ruland M.
WRIGHT, Natalie Louise

New Mexico

ARCHIBALD, Erwin R.
BRANDALISE, Bob B.
MEIGS, Purdy F.

New York

ASSELIN, N. D.
BENNETT, Corwin A.
BOWEN, George W.
CAREL, Walter L.
CHRISTIAN, John F.
CONTINI, Renato
DAVIS, Harry L.
DE BONS, Anthony
DEMBNER, Elliot
DE TOGNI, Gino R.
DRILLIS, Rudolfs J.
FARNSWORTH, Dean
FUGAZZI, Carlo
GOLDMAN, Alexander
GOLDSMITH, C. Thomas
HOCKENBERRY, Jack K.
HOLMES, Robert W.
HOUGHTON, Richard A., Jr.
HUNTOON, Richard B.
IBISON, Richard A.
JANSKY, Curtis M.
KORNFIELD, Alfred T.
KUBY, Milton
LEDERER, Jerome F.

LITT, Bertram D.
LYMAN, Arthur L.
MICHELI, Gene S.
MILBOUER, John A.
MILLER, Robert B.
MURPHY, Eugene F.
MURRAY, Richard T.
ORERT-THORN, William C.
OZKAPTAN, Halim
PECORARO, Joseph N.
PEIZER, Edward
RUDIGER, Thomas F.
SCHROEDER, Arthur H.
SEITZ, Clifford P.
SIMON, George B.
SLOTE, Lawrence
SMITH, Wellington E.
SNYDER, David M.
SPRAGG, S. D. Shirley
STIEGLITZ, William I.
STONE, Gerald
VAN COTT, Harold P.
VANDENBERG, John D.
WASSERMAN, Walter L.
WITTECK, Frank A.

Ohio

ALEXANDER, Milton
CACIOPPO, Anthony J.
CHRISTENSEN, Julien M.
CHRISTNER, Charlotte A.
COLBERT, Charles
GRETHER, Walter F.
HANES, Lewis F.
HERTZBERG, H. T. E.
HOWLAND, Daniel
KERBER, Harold E.
KIDD, Jerry S.
MAUCH, Hans A.
NARVA, Marshall A.
OBERMAYER, Richard W.
ORNSTEIN, George N.
PARKER, James W.
PORTER, Eugene M.
RITCHIE, Malcolm L.
SCHOHAN, Benjamin
SCHUTZ, Howard G.
SHELTON, Sid Watts
SKLODOWSKI, Vladimir A.
SPAULDING, Roy H.
STECH, Ernest L.
TRABOLD, Frederick W.
WEBB, Paul

Oklahoma

DICKEY, Frank L.
MCFADDEN, Ernest B.
OLSON, Bernard A.
SWEARINGEN, John J.

Oregon

DANIELS, Farrington, Jr.

Pennsylvania

BURGESS, George G.
CARTER, Robert E.
COLMAN, Kenneth W.
CORSO, John F.
COURTNEY, Douglas
DANAHER, James W.
EWING, Ronald W.
FLANAGAN, John C.
FOLLEY, John D.
GARDNER, Robert L.
GLASER, Robert
GRANT, George
HOBAN, Charles F.
KARROLL, Joseph E.
LATHROP, P. A.
MENEAR, Walter R.
SIEGEL, A. I.
SNYDER, Monroe B.

Texas

CHAFFEE, John W.
DOUGHERTY, Dora J.
HARTMAN, Bryce O.
HUCHINGSON, R. Dale
LATHAM, Albert J.
MATHENY, William G.
MCTEE, A. C.
MILLER, Charles O.
OUTCALT, N. R.
SCHULZE, Victor E., Jr.
SWEDA, Michael

Utah

WHITLOCK, Coleman M.

Virginia

AMES, Smith W.
BARBER, Jacob L., Jr.
BARKER, William S.
CARSTATER, Eugene D.
HEMBREE, Howard W.
IRELAND, Richard J.
MARTIN, Deloss K.
OLDER, Harry
SLEIGHT, Robert B.
SONTAG, Harcourt
TAYLOR, Franklin V.
VOAS, R. B.
WILLIAMS, Herman L.

Washington

BAMFORD, Harold E., Jr.
DITTMAN, Paul E.
QUEAL, Ralph W., Jr.
RICKARD, Harold J.
SHEARER, James W.
WATSON, Warren N.
WHITNEY, Clair G.
WORLEY, Milton S.

Wisconsin

BOSTROM, Karl A.
FERWERDA, Gerald J.
RADKE, Arthur O.
SCHMITZ, Melvin A.
SIMONS, Allison K.

Book Review

RESEARCH TECHNIQUES IN HUMAN ENGINEERING by Alphonse Chapanis

The Johns Hopkins Press, Baltimore, 1959. xii + 316 pp. Price $6.00.

During his distinguished career Alphonse Chapanis has pioneered many of the areas of human factors applications of experimental psychology as a scientist, teacher, industrial consultant, and writer. As a co-author of *Applied Experimental Psychology: Human Factors in Engineering Design,* published in 1949, he contributed to the first textbook specifically directed to the field—a textbook that is still widely consulted. Ten years later his *Research Techniques in Human Engineering* is likely to become another "must" for the bookshelf of every professional human factors worker. It is written in the same lucid style with the personal touch for which his writing is noted. It contains numerous examples and each idea is developed to a focused conclusion that is highly practical and, at least to this reviewer, a pleasant relief from much of the fuzzy psychological writing that is offered to engineering science. On page 3 he states: "The aim of this book is twofold. Its first purpose is to describe some of the methods available to the human engineer for collecting trustworthy data on men and machines and the relationships between them. Its second purpose is to discuss some principles and guide lines about ways of doing dependable studies on people . . . . examples of both good and bad studies are discussed here since I have relied heavily on the method of example as the best way of explaining principles."

The book itself is based on a major expansion of a monograph entitled *The Design and Conduct of Human Engineering Studies* which Chapanis prepared for the Executive Council of the Joint Services Steering Committee for the Human Engineering Guide to Equipment Design published in 1956. As a text, it is suitable for introducing the field of human factors engineering to engineering students at the senior or graduate level as well as to students in the behavioral or life sciences. The main title for each of the eight chapters gives some indication of the scope of the content:

1. Introduction
2. Methods of direct observation
3. Methods for the study of accidents and near-accidents
4. Statistical methods
5. The experimental method
6. Some special problems in experimenting with people
7. The psychophysical methods
8. Articulation testing methods

One hundred and eighteen references are listed. Among them are many contemporary books and articles which should serve to lead the serious reader into expansions of detail that were necessarily left out of *Research Techniques* in order to keep the broad subject manageable. The reader's use of his listed references, for example, should probably be considered a necessary routine for the matters discussed in the chapter on statistics. In this chapter it is regrettable that in developing the various topics, no statement is made regarding the particular power which non-parametric statistics have for applied problems where mathematical assumptions cannot be met and where differences that are large enough to be "practical" are of special importance. The latter factor as well as the relative ease of computing have made the somewhat lower statistical sensitivity of non-parametric methods generally acceptable for applied work, and it is probable that they should have a prominent place in the tool kit of professional human factors personnel. Siegel's *Nonparametric Statistics for the Behavioral Sciences* is

included in the bibliography and should be found useful to help enlarge on the content and viewpoint of statistical method as Chapanis interprets it in his 51 page presentation.

The material in chapters 2, 3, and 6 appears to be particularly useful as it brings together into one place many of the viewpoints and techniques that have hitherto been widely scattered through the literature; in many cases the content covered would probably remain unknown to the practical worker without the contribution which Professor Chapanis has made through his book. In contrast, the details of Chapter 8 are widely available and are specific to a single line of application.

Overall, *Research Techniques* is a highly readable, highly practical, and fairly complete presentation of the contemporary methods which are available to engineering psychologists. Other human factors engineering specialists will almost certainly help to make the well taught lessons of the book part of their own art.

John Lyman
UCLA

The Authors

ALPHONSE CHAPANIS and LIONEL E. LINDENBAUM (*A Reaction Time Study of Four Control-Display Linkages.*)

ALPHONSE CHAPANIS is professor of psychology and industrial engineering at The Johns Hopkins University. He has been associated with the Department of Psychology at The Johns Hopkins University since 1946, except for one year when he took a year's leave of absence to serve as a member of the technical staff at the Bell Telephone Laboratories, Murray Hill, New Jersey.

Born in Connecticut, he received his A.B. degree in psychology from the University of Connecticut in 1937, his M.A. in psychology from Yale University in 1942, and his Ph.D. in psychology from Yale in 1943. From 1942 to 1946 he served first as a civilian then as an officer with the Aero Medical Laboratory, Wright Air Development Center. His major work was on visual problems. When he left the Laboratory, he was Chief of the Vision Unit, and had the rank of Captain, Air Corps.

Chapanis is a Fellow of the American Psychological Association, a Life Member of the American Association for the Advancement of Science, a member of the Eastern Psychological Association, the American Institute of Physics, the Optical Society of America, the Society of Experimental Psychologists, and the National Society of the Sigma Xi. He has served on a number of government committees and as a consultant to many engineering firms.

He is the author of over 50 scientific books and articles published through regular channels, and an equal number of unpublished government research reports and memoranda on human engineering, vision, experimental design, statistics, and general experimental psychology.

LIONEL LINDENBAUM was born in Vienna, Austria. He received his A.B. degree in business and industrial management from the Johns Hopkins University in 1956. He is now attending the Bernard Baruch School of Business, City College, New York.

PAUL R. TOBIAS (*Effects of Radiation on Performance*) was a Research Engineer in the Human Factors group of the Missile Division, North American Aviation Inc., where he was concerned with psycho-physiological parameters of man in missile and space systems. He is now with Kerckhoff Laboratories, School of Medicine, University of Southern California. He is currently studying for an advanced degree in the Department of Psychology at the University of Southern California. He is a member of the Aerospace Medical Association.

Mr. Tobias attended Brown University and the University of California at Berkeley where he concentrated in the area of physiological psychology.

ERNEST B. McFADDEN, JOHN J. SWEARINGEN and C.D. WHEELWRIGHT (*The Magnitude and Direction of Forces that Man Can Exert in Operating Aircraft Emergency Exits.*)

ERNEST B. MCFADDEN is a Research Associate Physiologist in the Civil Aeronautics Medical Research Laboratory (CAMRL), Federal Aviation Agency, Aeronautical Center, Oklahoma City, Oklahoma, where he has worked since 1949. He was born in Omaha, Nebraska, and completed his undergraduate work at Kansas State Teachers College, Pittsburg, Kansas, and Oklahoma City University. He served in the U.S. Navy for 3 years. He received his MS degree from the Ohio State University and has completed additional graduate work in aviation physiology. He is author and coauthor of several journal articles and technical papers. His work has been primarily on projects in the fields of respiration, vertical deceleration, emergency evacuation, explosive decompression and escape. He and Mr. Swearingen have recently developed and patented a new concept in oxy-

gen mask design. He is Senior Investigator in the Physiology Section of CAMRL.

JOHN J. SWEARINGEN is Chief of the Civil Aeronautics Medical Research Laboratory (CAMRL), Federal Aviation Agency, Aeronautical Center, Oklahoma City, Oklahoma, where he has worked since 1948. He was born in Carter, Montana, and attended Purdue University, W. Lafayette, Indiana, where he graduated with BS and MS degrees. He majored in physiology, physics and mathematics and minored in education. He is a member of Sigma Xi, American Association for Advancement of Science, Human Factors Society, honorary faculty member of Ohio State University, School of Preventive Medicine. He designed and constructed the first articulated dummy for crash testing research. He is co-patentee on an oxygen mask. He was awarded the Exceptional Service Gold Medal and Superior Accomplishment awards by the Department of Commerce for studies in explosive and rapid decompression.

He served 5 years as aviation physiologist with U. S. Navy. Served as Head, Physical Medicine School, Naval Medical School Staff, Bethesda, Maryland, for 2 years. He served in Bureau of Medicine and Surgery, Washington, D. C.; Research Investigator NMRI, Bethesda, Maryland; Health & Sanitation Officer; trained naval personnel in physiological dangers of high altitude flying. He was mathematics and science high school teacher for 6 years, and 11 years in his present position. He is author and coauthor of numerous journal articles and technical papers, and has lectured at symposiums, conventions, etc.

CHARLES D. WHEELWRIGHT is a research assistant, human biologist, Civil Aeronautics Medical Research Laboratory (CAMRL), Federal Aviation Agency, Aeronautical Center, Oklahoma City, Oklahoma. He became associated with CAMRL in 1954 when it was located at Ohio State University, Columbus, Ohio, and has worked with the Human Factors Group. He was born in Ogden, Utah, and attended Denver University, Denver, Colorado, where he received a diploma in Glider Flight and Instruction. He received his BS degree in zoology from the University of Maryland. Two years military service with the 8th Air Force was spent in England. He attended Ohio State University and George Washington University doing graduate work. He worked three years as a biologist in the Laboratory of Low Energy Radiation, National Institute of Health, Bethesda, Maryland. His work has been primarily in fields of evacuation and escape, emergency oxygen, and human tissue characteristics.

FREDERICK A. MUCKLER (*Human Factors Research on Weapons Systems Project Teams*) has been a member of the Human Factors Section of The Martin Company, Baltimore Division since 1956. He is presently on field assignment to Wright Air Development Center where he is acting as principal investigator on a contract "Human Engineering Support to the Air Force Flight Control and Flight Display Integration Program." His academic training was in experimental psychology at the University of Illinois. He served as a member of the Aviation Psychology Laboratory at the University of Illinois from 1951 to 1956, and worked on a number of basic and applied research programs in the field of applied experimental psychology.

CAROL S. EVANS (*A Marginal Punched Card System for Human Factors Literature*) is a technical assistant in the Human Factors Group, Douglas Aircraft Company, Santa Monica. She was born in Philadelphia, Pennsylvania. She attended two colleges in the Midwest (Northwestern, Miami U.), and received her B.A. degree in English from the University of California at Los Angeles in June, 1959. Mrs. Evans joined the Human Factors Group in 1955, and helped to set up the punched card system described in the article.

DONALD B. DEVOE and EZRA V. SAUL (*The Tufts Index to Human Engineering Literature.*)

DONALD B. DEVOE is a research psychologist at the Operational Applications Laboratory, Air

Force Cambridge Research Center. He obtained his B.A. degree in physics in 1941 and his M.A. in psychology in 1947, both at the University of Maine. His Ph.D. was obtained at the University of Rochester in 1952. Research in motor skills, psychological measurement and statistics were his major activities prior to his present assignment. He is currently concerned with the integration of human factors into system developments. Mr. Devoe has an interest and considerable experience in the field of human factors documentation.

EZRA V. SAUL is Director of the Institute of Applied Experimental Psychology and associate professor of psychology at Tufts University. He obtained his Ph.D. at Ohio State University in 1951 after completing his B.S. and M.A. at the University of Connecticut. He has done research in the areas of human engineering and military training. More recently, he has directed the Human Engineering Information and Analysis Service Project at Tufts under the sponsorship of the three military services.

HAROLD E. BAMFORD, JR. (*Human Factors in Man-Machine Systems.*) See *Human Factors*, 1, No. 2, 51, 1959. Dr. Bamford is now senior group engineer at Boeing Airplane Co., Seattle, Washington.

ROBERT B. SLEIGHT (*Directory of Members*) is President of the Applied Psychology Corporation whose headquarters are in Arlington, Virginia. A native of New York State, he served as naval aviator during World War II, then attended Purdue University. He was awarded the Ph.D. degree in 1948. His major program of study was in industrial psychology. Since 1948, he has been active in human engineering research. He was assistant professor at the Johns Hopkins University until his present affiliation commenced in 1952. Dr. Sleight is Chairman of the Membership Committee of the Human Factors Society.

EAST AND WEST

Everybody and every organization has to be born at some time and in some place. An urgent need for interdisciplinary communication in the man-machine-environment field arose out of the concentration of aircraft and missile work in Southern California. This communication process actually started in 1943 under the sponsorship of people from the University of Southern California. The number and population density of individuals in this area made it physically possible to communicate with one another easily. The continued enthusiasm of this local group for more than a decade was sufficient to support the tedious organizational effort which led to the Tulsa Constitutional Convention in 1957. Since Tulsa, there has been a steady growth and diversification of the Society in terms of the academic background and geographical representations of our members. However, during the September 1959 meetings in Los Angeles, we were told that some members felt that the West exerted an undue influence in Society affairs.

Such feelings can be harmful and divisive in a young and active organization such as ours, so we attempted to run a few objective checks on possible bias. First, Caeser-like, we divided the world into two parts, east and west of the Mississippi. To simplify calculations, we included only the old 48 states of the United States of America, and the District of Columbia. Then we counted whatever could be counted to establish some verifiable observations.

Three easterners and seven westerners formed the executive council and officers for the interim period before the first elections.

Eight easterners and four westerners served in the same capacity as a result of the 1958 elections.

Seven easterners and six westerners now serve as officers and executive council as a result of the 1959 elections. Most of the officers are from the West, most of the executive council from the East.

In Volume I of this journal, 15 articles were by easterners, 8 by westerners.

A check of the participants of the September meeting at UCLA showed 23 easterners and 23 westerners on the program.

A total of 314 persons attended the UCLA meetings, 93 of these were from the East.

This is the record. It does not appear to us that a strong and persistent bias against technical or professional participation in the affairs of our Society is based upon geography. We trust that such a bias never will arise.

Stanley Lippert

EXCELLENT OPPORTUNITIES FOR

PSYCHOLOGISTS

You are invited to investigate unusual career opportunities with excellent futures in the science and engineering Laboratories of IBM. You will find this to be a unique opportunity to contribute original thinking on several important projects.

Our Laboratories are engaged in the research and development of advanced electronic digital computers for business, science and industry. We are also engaged in the design of control systems for exotic-fueled strategic bombers to operate at altitudes above 70,000 feet and at speeds of more than 2,000 miles per hour.

- To undertake design, research, experimental analysis, and consultation in the field of man-machine relationships in a newly organized psychology group. Unusual opportunities for display and systems design in the early development stage. Projects include work in psychophysics, communications, electronics, trouble-shooting techniques, human learning, perception, operations analysis, high-speed data processing, psychometrics, information theory, decision processes, visual and auditory displays, and equipment design. Program includes both applied and basic experimentation. An advanced degree is required, or considerable experience in appropriate fields.

- To conduct systems analysis on complex, advanced weapons systems. A strong background in mathematics and statistics is desirable. An M.A. or Ph.D. in Psychology is required with experience in human engineering and human factors research.

- To initiate human factors design on Navy programs. Experience either on naval systems or equipment is highly desirable. An M.A. or Ph.D. in experimental psychology is required.

- To perform equipment evaluation experimentation, laboratory simulation, and flight test analysis from the human factors standpoint. An M.A. or Ph.D. in Psychology is required plus applied experimental experience.

- PERSONNEL AND TRAINING PSYCHOLOGIST to conduct maintenance and handling task-equipment analysis and other personnel analyses on advanced electronic systems. Knowledge of Air Force skill classifications and technical training and related equipment is desirable. Must have knowledge of airborne weapons system research and development cycle. An M.A. or Ph.D. in Psychology is required with specialization in industrial and engineering applications of psychological knowledge and techniques.

• • •

Salary commensurate with experience. Advancement based on merit. Employee benefits are among the best in industry today.

Please write, including resume, to:

Mr. R. E. Rodgers, Dept. 700 J
International Business Machines Corp.
590 Madison Avenue
New York 22, N. Y.

IBM®

INTERNATIONAL BUSINESS
MACHINES CORPORATION